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**BUREAU OF WATER AND WASTEWATER
WATER & WASTEWATER ENGINEERING DIVISION**

**Jones Falls Sewershed Evaluation Study Plan
Project 994**

Alternative Analysis and Recommendations

**Sanitary Sewer Overflow Consent Decree
Civil Action No. JFM-02-1524**

**DRAFT Submission
November 2008**

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in association with



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EXECUTIVE SUMMARY

As part of Baltimore City Project No. 994, Rummel, Klepper and Kahl, LLP and KCI Technologies, Inc. have developed a calibrated hydraulic model of the Jones Falls sewershed within the City of Baltimore. The calibrated model was then utilized to simulate a series of design storm rain events to identify possible sanitary sewer overflow locations. This report outlines the recommendations for the elimination of sanitary sewer overflows from the Jones Falls collection system due to wet weather inflow and infiltration up to a 20-year, 24 hour storm event.

A Consent Decree was agreed upon between the City of Baltimore, the United States Environmental Protection Agency and the Maryland Department of the Environment, executed in April, 2002 and issued May, 2002. As stipulated on page 22 of the Consent Decree, the City of Baltimore shall identify all components that cannot manage peak flows during a full range of storm events. The City shall then identify the required improvements necessary to ensure long term capacity with no sanitary sewer overflows for the full range of storm events. These design storms include: the three-month storm having a duration equal to the time of concentration for the sewershed (5 hours); the 20-year 24-hour duration storm; and the 1-, 2-, 5-, 10-, and 15-year, 24 hour storms.

Per the Consent Decree and the City of Baltimore, the improvements Baltimore shall consider to assure adequate capacity shall include but not be limited to replacement of malfunctioning pumping station equipment, installation of pumping station back-up equipment, reduction of inflow and infiltration, installation of larger replacement sewers or relief sewers, sewer pressurization (gravity system pressurized by head), and storage (both inline and offline).

In designing improvements, emphasis was placed on I&I removal from upstream locations of the identified sanitary sewer overflow locations. Information from the closed circuit television inspections, flow metering results, and smoke/dye testing were utilized in selecting the areas for inflow and infiltration removal. From the technical program guidelines provided by the City, a comprehensive inflow and infiltration removal program (cured in place pipe lining of all public and private sewers and manhole rehabilitation/replacement) it is estimated that up to 80 percent of rainfall dependant inflow and infiltration and dry weather infiltration can be removed from the system. It is proposed to only rehabilitate the public side of the collection system; therefore the model was modified to only account for a 40 percent reduction in rainfall dependant inflow and infiltration and dry weather infiltration in the locations selected for inflow and infiltration reduction. Following inflow and infiltration removal, the next step to remove sanitary sewer overflows was upsizing pipes or adding relief sewers, adding storage, pump station upgrades and sewer pressurization. No consideration was taken for any inflow and infiltration removal or other changes in flows from Baltimore County. However, any inflow and infiltration reduction the County can achieve has the potential to reduce the required improvements within the City's collection system.

To develop the estimated costs of construction, standard unit prices were provided by the City in 2008 dollars. The costs provided were fully loaded costs to address such items as mobilization, maintenance of traffic, paving restoration, bypass pumping and miscellaneous (non-sanitary)



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utility work. In addition to these costs, the items are escalated an additional 42 percent to accommodate engineering design, construction management/inspection, administration, post-award engineering services and contingencies. A 7 percent annual inflation rate is used to project costs for years beyond 2008.

To convey the two-year storm event the main construction project are required only in the Lower Jones Falls, Maryland Avenue, Stony Run, Upper Jones Falls, and Western Run Sub-Sewersheds. The most critical project for the two-year storm is to clean the Lower Jones Falls Interceptor. The combined improvement cost to convey the two-year storm is estimated to be \$21.7 million in 2008 dollars. The average cost to eliminate each gallon of estimated overflow is \$2.26 in 2008 dollars

Improvements are required in all of the sub-basins, except the Barclay Street sub-basin to handle the five-year storm event without an overflow following implementation of the improvements for the two-year storm. The work required mainly involves inflow and infiltration reduction projects and smaller diameter pipe size increases (8 and 10-inches increased to 12-15-inches). The largest project for the 5-year event is increasing one of the parallel interceptors in Western Run from 24-inches to 30-inches. The combined improvement cost to convey the five-year storm is estimated to be \$67.8 million in 2008 dollars. The average cost to eliminate each gallon of overflow is estimated to be \$2.88 in 2008 dollars, however, the cost to eliminate the overflows moving from the 2-year improvements to the 5-year improvements is estimated to be \$10.72 per gallon in 2008 dollars.

Improvements for the ten-year storm are required in all the sub-sewersheds in the Jones Falls collection system. The work in addition to the improvements for the five-year event, increasing the size of the Maryland Avenue Siphon, the addition of two storage facilities in the Upper Jones Falls (1.25 million gallons near Western Run, and 3.75 million gallons near the Jones Falls Pumping Stations), smaller diameter pipe size increases (8 and 10-inches increased to 12-15-inches), and additional inflow and infiltration reduction projects. The combined improvement cost to convey the ten-year storm is estimated to be \$152.3 million in 2008 dollars. The average cost to eliminate each gallon of overflow is estimated to be \$4.71 in 2008 dollars; however, the cost to eliminate the overflows moving from the 5-year improvements to the 10-year improvements is estimated to be \$29.62 per gallon in 2008 dollars

To convey the fifteen-year storm event without sanitary sewer overflows, work is required in only Greenmount, Lower Jones Falls, Stony Run, Upper Jones Falls, and Western Run sub-basins. The work to convey the 15-year event, in addition to the ten-year event involves additional inflow and infiltration removal projects, smaller size pipe diameter increases, a 60-inch relief sewer in the Lower Jones Falls or pressurizing the existing interceptor, and the addition of a 3.0 million gallon storage tank near Western Run and a 3.75 million gallon tank near the Jones Falls Pumping Station. The combined improvement cost to convey the fifteen-year storm is estimated to be \$227.3 million in 2008 dollars. The average cost to eliminate each gallon of overflow is estimated to be \$6.06 in 2008 dollars; however, the cost to eliminate the overflows moving from the 10-year improvements to the 15-year improvements is estimated to be \$147.91 per gallon in 2008 dollars



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To convey the twenty-year storm event without sanitary sewer overflows, work is required in all the sub-basins except Bolton Hill and Maryland Avenue. The work necessary to convey the twenty-year storm involves additional pipe size increases, an additional 60-inch relief sewer in the Lower Jones Falls, a 6.75 million gallon storage tank new the Jones Falls Pumping Station and a 2.25 million gallons tank near Western Run, increasing the parallel sewers in Western Run to 24 and 30-inches. The combined improvement cost to convey the twenty-year storm is estimated to be \$314.5 million in 2008 dollars. The average cost to eliminate each gallon of overflow is estimated to be \$7.45 in 2008 dollars; however, the cost to eliminate the overflows moving from the 15-year improvements to the 20-year improvements is estimated to be \$332.38 per gallon in 2008 dollars.

Total Estimated Improvement Costs for Jones Falls					
Projected Year	2 Year	5 Year	10 Year	15 Year	20 Year
2008	\$21,680,000	\$67,750,000	\$152,280,000	\$227,300,000	\$314,450,000
2009	\$23,200,000	\$72,490,000	\$162,940,000	\$243,210,000	\$336,460,000
2010	\$24,820,000	\$77,560,000	\$174,350,000	\$260,230,000	\$360,010,000
2011	\$26,560,000	\$82,990,000	\$186,550,000	\$278,450,000	\$385,210,000
2012	\$28,420,000	\$88,800,000	\$199,610,000	\$297,940,000	\$412,170,000
2013	\$30,410,000	\$95,020,000	\$213,580,000	\$318,800,000	\$441,020,000
2014	\$32,540,000	\$101,670,000	\$228,530,000	\$341,120,000	\$471,890,000
2015	\$34,820,000	\$108,790,000	\$244,530,000	\$365,000,000	\$504,920,000
2016	\$37,260,000	\$116,410,000	\$261,650,000	\$390,550,000	\$540,260,000
2017	\$39,870,000	\$124,560,000	\$279,970,000	\$417,890,000	\$578,080,000

Estimated Improvement Costs Per Gallon SSO Removed									
	2 Year	5 Year		10 Year		15 Year		20 Year	
		Add.	Cum.	Add.	Cum.	Add.	Cum.	Add.	Cum.
2008	\$2.26	\$10.72	\$2.88	\$29.62	\$4.71	\$147.91	\$6.06	\$332.38	\$7.45
2009	\$2.42	\$11.47	\$3.09	\$31.70	\$5.04	\$158.26	\$6.49	\$355.64	\$7.97
2010	\$2.59	\$12.27	\$3.30	\$33.92	\$5.39	\$169.32	\$6.94	\$380.55	\$8.53
2011	\$2.77	\$13.13	\$3.53	\$36.29	\$5.77	\$181.19	\$7.43	\$407.17	\$9.12
2012	\$2.97	\$14.05	\$3.78	\$38.83	\$6.17	\$193.87	\$7.95	\$435.66	\$9.76
2013	\$3.17	\$15.03	\$4.05	\$41.55	\$6.60	\$207.45	\$8.50	\$466.13	\$10.45
2014	\$3.40	\$16.08	\$4.33	\$44.45	\$7.07	\$221.98	\$9.10	\$498.74	\$11.18
2015	\$3.63	\$17.21	\$4.63	\$47.57	\$7.56	\$237.52	\$9.73	\$533.64	\$11.96
2016	\$3.89	\$18.41	\$4.96	\$50.90	\$8.09	\$254.14	\$10.42	\$570.98	\$12.80
2017	\$4.16	\$19.70	\$5.30	\$54.46	\$8.66	\$271.92	\$11.14	\$610.95	\$13.69



1.0 PROJECT DESCRIPTION

1.1 Project Location

The Jones Falls Sewershed encompasses approximately 16.5 square miles within the City of Baltimore, as depicted on Map 1.1. Sewage from Baltimore County flows into the City's Jones Falls sewershed at six locations. The sewershed population within the City is approximately 144,000 and is highly developed. The study area includes the Jones Falls Sewershed and consists of approximately 1,600,000 linear feet (LF) of gravity sewer ranging from 6 to 75-inches in diameter; approximately 8,000 manholes and structures; 37,000 LF of force main and pressure sewer, three siphons; and two sewage pumping stations.

The Jones Falls sewershed encompasses a section of the city in the north central portion of the City. The boundaries are roughly York Road to the east, Park Heights Avenue on the west, and the City-County line on the north and Preston Street on the south.

1.2 Sub-Sewersheds

The Jones Falls Sewershed consists of a total of nine sub-sewersheds. These are listed in Table 1.2 below:

TABLE 1.2	
SUB-SEWERSHEDS WITHIN THE JONES FALLS SEWERSHED	
Upper Jones Falls	Barclay Street
Lower Jones Falls	Greenmount Avenue
Western Run	Bolton Hill
Stony Run	Maryland Avenue
Hampden Avenue	

The boundaries for each of the sub-sewersheds are depicted on Map 1.1.

1.3 Consent Decree Requirements

A Consent Decree (CD) was agreed upon between the City of Baltimore, the United States Environmental Protection Agency and the Maryland Department of the Environment, executed in April, 2002 and issued May, 2002. As stipulated on page 22 of the CD, the City of Baltimore shall identify all components that cannot manage peak flows during a full range of storm events. The City shall then identify the required improvements necessary to ensure long term capacity with no sanitary sewer overflows for the full range of storm events. These design storms include: the three-month storm having a duration equal to the time of concentration for the sewershed (5 hours); the 20-year 24-hour duration storm; and the 1-, 2-, 5-, 10-, and 15-year, 24 hour storms.

1.4 Guidelines and Requirements

As specified in the Consent Decree, the future conditions model shall be used to determine the requirements necessary to convey all the flows without a sanitary sewer overflow (SSO). The future conditions model, as outlined in the *Baseline Analysis and Capacity Assessment Report*, dated August, 2008, projects the population to year 2025 and includes a 10% increase in average daily infiltration to account for pipe deterioration.

Per the CD and the City of Baltimore, the improvements Baltimore shall consider to assure adequate capacity shall include but not be limited to replacement of malfunctioning pumping station equipment, installation of pumping station back-up equipment, reduction of inflow and infiltration, installation of larger replacement sewers or relief sewers, sewer pressurization, and storage (both inline and offline).

1.5 Alternative Section Process

The minimum design requirement for City of Baltimore is the ability to convey at least a 2-year storm event. Based on this, the required upgrades to only convey the 3-month storm, and 1-year storm were not examined. The analysis begins with the required improvements necessary to convey the 2-year event with out any SSOs.

In designing improvements, emphasis was placed on inflow and infiltration (I&I) removal from upstream locations of the identified SSO locations. Information from the closed circuit television (CCTV) inspections, flow metering results, and smoke/dye testing were utilized in selecting the areas for I&I removal. From the technical program guidelines provided by the City, a comprehensive I&I removal program (cured in place pipe (CIPP) lining of all public and private sewers and manhole rehabilitation/replacement) it is estimated that up to 80 percent of rainfall dependant inflow and infiltration (RDII) and dry weather infiltration can be removed from the system. It is proposed to only rehabilitate the public side of the collection system, therefore the model was modified to only account for a 40 percent reduction in RDII and dry weather infiltration in the locations selected for I&I reduction. Following I&I removal, the next step to remove SSOs was upsizing pipes or adding relief sewers, adding storage, pump station upgrades and sewer pressurization. No consideration was taken for any I&I removal or other changes in flows from Baltimore County. The County is in the beginning phases of their Consent Decree with the Environmental Protection Agency (EPA), which will not be completed for several years after the Jones Fall Sewershed Study is scheduled to be completed. However, any I&I reduction the County may achieve introduces additional margin of safety for the recommended improvements.

1.6 Assumptions

In performing the hydraulic model simulations for the required design storm events, the following assumptions were made:

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- a. Year 2025 estimated average daily flow rates with diurnal peaking factors and a 10 percent increase of daily infiltration from baseline conditions.
- b. There would be no I&I reduction from the adjacent jurisdictions, mainly Baltimore County. This assumption introduces considerable wet-weather flows that are likely to be eliminated as Baltimore County implements I&I reduction and peak flow attenuation projects as part of their Consent Decree.
- c. The City would experience system-wide storms across all sewersheds. Historically, the Baltimore Metro Area experiences localized storms, and the chance of a system-wide storm is unlikely. This assumption creates extreme conditions and yields conservative alternatives and oversized improvements.
- d. Assume the NRSC-NOAA rainfall distribution, which is a synthetic distribution representing severe conditions and worst case scenario. This assumption creates extreme conditions and yields conservative alternatives and oversized improvements as well.
- e. Use the InfoWorks SWM Runoff routine in conjunction with the average capture coefficient (R) generated from the I&I evaluation. Winter storms typically generate higher R than summer storms. This is because in the winter the ground water table is higher; hence, more rainfall ends up in the sanitary sewer. In the summer conditions reverse. Dry soils and surface evaporation result in less rainfall finding its way to the sanitary pipes as the ground water table is lower due to evaporation, and a greater withdrawal by vegetation or is absorbed by the ground - this in spite the fact that summer storms are typically of greater magnitude. Using the average of the summer and winter R introduces a safety margin by allowing a higher than normal R during the more severe summer storms.
- f. Does not take into account other system wide improvements that are required based on the condition and criticality ranking of the sewage system components, which may decrease the severity of rainfall dependent inflow and infiltration.

The assumptions outlined above create inflated wet-weather flows and introduce several layers of safety margins that make the recommended improvements larger than necessary and likely capable of handling larger storm events.

To develop the estimated costs of construction, standard unit costs for sewer point repairs, sewer lining, sewer replacement, and manhole rehabilitation/replacement were provided by the City in 2008 dollars. The costs provided were fully loaded costs to address such items as mobilization, maintenance of traffic, paving restoration, bypass pumping and miscellaneous (non-sanitary) utility work. For costs not provided by the City (cleaning, storage, and pumping stations for example) recent projects within the City and surrounding areas were reviewed to assist in estimating the most probable fully loaded cost of construction. In addition to these costs, the items are escalated an additional 42 percent to accommodate engineering design, construction



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management/inspection, administration, post-award engineering services and contingencies. A 7 percent annual inflation rate is used to project costs for years beyond 2008.

2.0 2-YEAR IMPROVEMENTS

See Map 2.0 for a detailed map showing the locations of the following projects described on a sub-sewershed basis.

2.1 Barclay Street

No Required Improvements.

2.2 Bolton Hill

No Required Improvements.

2.3 Greenmount Avenue

No Required Improvements.

2.4 Hampden Avenue

No Required Improvements.

2.5 Lower Jones Falls

From the *Baseline Analysis and Capacity Assessment* Report, there is an estimated volume of 9.2 million gallons of overflows. The largest cause of the overflows is the accumulation of sediment in the Lower Jones Falls Interceptor. From internal inspections, it is estimated that the pipe is half full of debris. This 50-inch to 75-inch sewer must be cleaned. The capacity of the 75-inch pipe would increase from 25 MGD to 78 MGD following cleaning. It is recommended to clean the entire Jones Falls Interceptor, beginning at the Falls Road Siphon, all the way to the High Level Interceptor. Once the sewer is clean, it is recommended to reassess the internal condition of the pipe to determine if further rehabilitation is required. The costs to clean the Lower Jones Falls are presented in Table 2.5.



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TABLE 2.5				
2-Year Lower Jones Falls Improvements				
Diameter	Rehab Method	Unit Cost	Quantity (Tons)	Cost
50-Inch Pipe (1,924 LF)	Heavy Cleaning	\$500/ton	850	\$425,000
56-Inch Pipe (370 LF)	Heavy Cleaning	\$500/ton	200	\$100,000
64-Inch Pipe (2,475 LF)	Heavy Cleaning	\$500/ton	1,800	\$900,000
75-Inch Pipe (1,534 LF)	Heavy Cleaning	\$500/ton	1,600	\$800,000
Manholes (each)	Rehab	\$3,719	20	\$74,380
Subtotal				\$2,299,380
Eng. Design, Const Mgt/Insp, Admin, Post Eng. Svcs & Cont. (42%)				\$965,740
2008 Total Estimated Cost				\$3,270,000
2009 Total Estimated Cost				\$3,500,000
2010 Total Estimated Cost				\$3,750,000
2011 Total Estimated Cost				\$4,010,000
2012 Total Estimated Cost				\$4,290,000
2013 Total Estimated Cost				\$4,590,000
2014 Total Estimated Cost				\$4,910,000
2015 Total Estimated Cost				\$5,250,000
2016 Total Estimated Cost				\$5,620,000
2017 Total Estimated Cost				\$6,010,000

2.6 Maryland Avenue

Maryland Avenue has the highest RDII rates and the highest average daily infiltration rates in the Jones Falls Sewershed. Therefore, it is recommended to perform an extensive I&I removal project in the Maryland Avenue sub-sewershed. It is recommended to CIPP all the pipes and rehabilitate all the manholes southeast of MH S31EE_021MH on Preston Street, all the pipes and manholes east of MH S33GG_010MH on Mt. Royal Avenue, and all the pipes and manholes west of MH S33GG_088MH on Oliver Street.

Following completion of the I&I removal projects, the total dry weather infiltration reduces from 483,000 gpd to 290,000 gpd with an annual convey and treat savings of \$105,100 (2008 dollars). The 2-year RDII reduces from 2.2 MG to 1.6 MG for a convey and treat cost savings of \$1,750 per storm.

On Preston Street, there is a reach of sewer that begins as a 10-inch pipe, increases to a 12-inch pipe, and then decreases to an 8-inch pipe, then increasing back up to a 12-inch pipe. The 8-inch pipe restricts the flow and causes SSOs for the 2-year storm event. It is recommended to increase these three pipe segments from MH S31EE_015MH to MH S31CC_011MH from 8-inches to 15-inches in diameter.



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The velocities through the Maryland Avenue siphon are relatively slow (average of about 0.5 fps and peaking at 1.5 fps) and the situation is compounded with the elevated sewage levels in the Lower Jones Falls Interceptor (LJF). With the low velocities, the pipe does not have the self cleaning effect available with higher velocities. Once the LJF Interceptor and the siphon are cleaned, velocities do increase, but not as high as required for self cleaning. Therefore, it is recommended to clean the siphon and place it on a regular cleaning schedule to minimize the chance for backups.

The estimate costs, in 2008 dollars, for the proposed upgrades to the Maryland Avenue sub-sewershed are presented in Table 2.6.

TABLE 2.6				
2-Year Maryland Avenue Improvements				
Item	Rehab Method	Unit Cost	Quantity (LF)	Cost
8-Inch Pipe	CIPP	\$45	15,258	\$686,610
10-Inch Pipe	CIPP	\$64	776	\$49,664
12-Inch Pipe	CIPP	\$87	203	\$17,661
15-Inch Pipe	Replacement	\$585	385	\$225,225
18-Inch Siphon	Clean	\$300	525	\$157,500
24-Inch Siphon	Clean	\$300	250	\$75,000
Manholes(each)	Rehab	\$3,719	127	\$472,313
Manholes(each)	Replacement	\$3,719	2	\$7,438
Subtotal				\$1,691,411
Eng. Design, Const Mgt/Insp, Admin, Post Eng. Svcs & Cont. (42%)				\$710,393
2008 Total Estimated Cost				\$2,400,000
2009 Total Estimated Cost				\$2,570,000
2010 Total Estimated Cost				\$2,750,000
2011 Total Estimated Cost				\$2,940,000
2012 Total Estimated Cost				\$3,150,000
2013 Total Estimated Cost				\$3,370,000
2014 Total Estimated Cost				\$3,610,000
2015 Total Estimated Cost				\$3,860,000
2016 Total Estimated Cost				\$4,130,000
2017 Total Estimated Cost				\$4,420,000

To convey and treat the wet weather events in the Maryland Avenue area rather than remove inflow, several reaches of pipe and the siphon will have to be increased in diameter. The estimated cost for this including the volume of rain conveyed and treated is \$3,300,000 versus the I&I removal cost of \$2,710,000 in 2008 dollars. I&I removal also saves a half a million dollars in construction costs, decreases the daily infiltration, and reduces peak flows that are passed to downstream sewersheds. Therefore, it is recommend to remove inflow versus convey and treating.



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2.7 Stony Run

For the 2-year event, the overflows in the Stony Run sub-basin are confined to two areas: one is the JF23 flow meter basin and the other is the JF26 flow meter basin. JF23 has elevated RDII levels that are corroborated with CCTV and smoke test data. The upstream meter basins of JF26, (JF27 and JF28) also have high levels of RDII with substantiating CCTV and smoke test data. Therefore, implementing an I&I removal contract in those three meter basins (JF23, JF27, and JF26) was analyzed. However, even after the hydraulic model has been modified to reflect such a project, overflows would still occur. The pipe sizes within those sub-catchments still need to be increased following an I&I removal project. The pipe sizes required are the same size if a RDII project is completed or not. For a 2-year storm, the benefits of a comprehensive I&I removal project do not appear to be worth the capital investment. Hence, it is recommended to convey and treat the infiltration rather than remove it. The 4,134 foot reach of 10-inch and 12-inch pipe between MH S35KK1001MH located in Underwood Road to MH S31GG1084MH in Linkwood Road needs to be upsized to 15-inch pipe. The 3,163 foot reach of 15-inch pipe between MH S33QQ1015MH located near the western terminus of Winston Avenue to MH S29OO1015MH located north of Cold Spring Road needs to be upsized to 21-inch diameter pipe. The added advantage for both of these reconstruction projects is the ability to smooth out the existing profile, lay the pipe at a steeper grade and elevate the manholes that do not lie within roadways. The costs associated with the convey and treat alternative are presented in Table 2.7.

TABLE 2.7				
2-Year Stony Run Improvements				
Item	Rehab Method	Unit Cost	Quantity (LF)	Cost
15-Inch Pipe	Replacement	\$585	4,134	\$2,418,390
21-Inch Pipe	Replacement	\$1,080	3,163	\$3,416,040
Manholes(each)	New	\$3,719	47	\$174,793
Subtotal				\$6,009,223
Eng. Design, Const Mgt/Insp, Admin, Post Eng. Svcs & Cont. (42%)				\$2,523,874
2008 Total Estimated Cost				\$8,530,000
2009 Total Estimated Cost				\$9,130,000
2010 Total Estimated Cost				\$9,770,000
2011 Total Estimated Cost				\$10,450,000
2012 Total Estimated Cost				\$11,180,000
2013 Total Estimated Cost				\$11,960,000
2014 Total Estimated Cost				\$12,800,000
2015 Total Estimated Cost				\$13,700,000
2016 Total Estimated Cost				\$14,660,000
2017 Total Estimated Cost				\$15,690,000



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The 2008 estimated cost for inflow and infiltration elimination plus the pipe replacement is estimated to be \$15.6 million. In addition to this cost, removing the excessive inflow saves an additional \$1,000 per a 2-year storm event and an additional \$105,000 per year in extra infiltration for convey and treat costs. These savings, however, do not justify the addition construction cost compared to the pipe replacement option.

2.8 Upper Jones Falls

As part of one of the Paragraph 8 construction projects of the CD, a new 48-inch diameter sewer was constructed in the Upper Jones Falls, under SC 824. As part of this project, an existing 42-inch sewer was abandoned in place and is isolated by a series of sluice gates. In the hydraulic model, if this line is reactivated, projected SSOs in the eastern portion of the Western Run sub-sewershed and the two engineered SSOs (33 and 34) do not activate. It is recommended to reactivate this reach of 42-inch sewer from Northern Parkway (MH S19CC2045MH) to Cold Spring Lane (MH S19OO1042MH). Since this line was abandoned, it was not internally inspected as part of the Paragraph 9 requirements of the CD. Therefore, it is proposed to internally inspect this reach of sewer and implement any required upgrades based on the inspection prior to reactivation. The costs for the required upgrades to convey the 2-year storm event for the Upper Jones Falls are presented in Table 2.8.

TABLE 2.8				
2-Year Upper Jones Falls Improvements				
Diameter	Rehab Method	Unit Cost	Quantity (LF)	Cost
42-Inch Pipe	CCTV	\$5	7,488	\$37,440
Open Sluice Gates (each)		\$1,000	4	\$4,000
Subtotal				\$41,440
Following CCTV, assuming the 42-Inch sewer requires rehabilitated				
42-Inch Pipe	CIPP	\$385	7,488	\$2,882,880
Manholes(each)	Rehab	\$3,719	30	\$111,570
Subtotal				\$2,994,450
Eng. Design, Const Mgt/Insp, Admin, Post Eng. Svcs & Cont. (42%)				\$1,275,074
2008 Total Estimated Cost				\$4,310,000
2009 Total Estimated Cost				\$4,610,000
2010 Total Estimated Cost				\$4,930,000
2011 Total Estimated Cost				\$5,280,000
2012 Total Estimated Cost				\$5,650,000
2013 Total Estimated Cost				\$6,050,000
2014 Total Estimated Cost				\$6,470,000
2015 Total Estimated Cost				\$6,920,000
2016 Total Estimated Cost				\$7,400,000
2017 Total Estimated Cost				\$7,920,000



2.9 Western Run

From the *Baseline Analysis and Capacity Assessment* Report, for the 2-year, 24-hour storm event, overflows are experienced at flow meter basins JFWR24 and JF03_20S. These are mainly due to high RDII in these basins. Based on prior smoke and dye testing data, several locations were identified in the flow meter basin JFWR24 where water from storm drain enters the sanitary sewer through leaking joints. In addition, many pipes were found to be in a deteriorated condition during the CCTV investigation. It is therefore, recommended to CIPP line all the pipes and rehabilitate manholes in this basin beginning at the most downstream MH S1CC2025MH located in Bancroft Road.

For the overflows upstream of flow meter JF03_20S, located in Baltimore County, it is recommended to upsize 1,675 feet of existing 8-inch pipe to 12-inch pipe, upstream of MH S06GG2006MH from Wallis Road northeast to the City/County boundary. An alternative would be for the City to negotiate with the County to reduce RDII. If the RDII from the County is reduced, then the required amount of improvements within the City would also be reduced.

After all these improvements, the average daily dry weather base infiltration volume will reduce from 174,000 gpd to 104,400 gpd for a yearly savings of \$40,000. The 2-year RDII volume will reduce from 0.9 MG to 0.5 MG for a per storm savings of \$ 600. The costs associated with all the improvements to convey the 2-year, 24-hour storm event are presented in Table 2.9.

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TABLE 2.9				
2-Year Western Run Improvements				
Diameter	Rehab Method	Unit Cost	Quantity (LF)	Cost
8-Inch Pipe	CIPP	\$45	13,101	\$589,545
10-Inch Pipe	CIPP	\$64	4,349	\$278,336
12-Inch Pipe	CIPP	\$87	411	\$35,757
12-Inch Pipe	Replacement	\$585	1,675	\$979,875
Manholes(each)	Rehab	\$3,719	87	\$323,553
Manholes(each)	Replacement	\$3,719	7	\$26,033
Subtotal				\$2,233,099
Eng. Design, Const Mgt/Insp, Admin, Post Eng. Svcs & Cont. (42%)				\$937,902
2008 Total Estimated Cost				\$3,170,000
2009 Total Estimated Cost				\$3,390,000
2010 Total Estimated Cost				\$3,630,000
2011 Total Estimated Cost				\$3,880,000
2012 Total Estimated Cost				\$4,150,000
2013 Total Estimated Cost				\$4,440,000
2014 Total Estimated Cost				\$4,750,000
2015 Total Estimated Cost				\$5,080,000
2016 Total Estimated Cost				\$5,440,000
2017 Total Estimated Cost				\$5,820,000

The estimated costs of improvements required to convey the 2-year event in the Western Run basin without I&I removal is \$4.9 million (2008 dollars), including the extra volume of water conveyed and treated. To convey the event, 5,730 feet of 8 and 10-inch pipe would have to be upsized to 12-inches in diameter in the JFWR24 flow meter basin. Due to the additional cost, this option was dropped from consideration.

2.10 2-Year Summary

The combined cost estimate for all improvements recommended to convey the 2-year, 24 hour storm event in the Jones Falls Sewershed is presented in Table 2.10. The two recommended I&I reduction projects are estimated to save the City approximately \$145,000 (2008 dollars) per year in treatment costs. The average cost to eliminate each gallon of estimated overflow is estimated to be \$2.26 in 2008 dollars.



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TABLE 2.10				
2-Year Jones Falls Improvements				
Diameter	Rehab Method	Unit Cost	Quantity (LF)	Cost
50-Inch Pipe (1,924 LF)	Heavy Cleaning	\$500/ton	850	\$425,000
56-Inch Pipe (370 LF)	Heavy Cleaning	\$500/ton	200	\$100,000
64-Inch Pipe (2,475 LF)	Heavy Cleaning	\$500/ton	1,800	\$900,000
75-Inch Pipe (1,534 LF)	Heavy Cleaning	\$500/ton	1,600	\$800,000
18-Inch Siphon	Clean	\$300	525	\$157,500
24-Inch Siphon	Clean	\$300	250	\$75,000
8-Inch Pipe	CIPP	\$45	28,369	\$1,276,605
10-Inch Pipe	CIPP	\$64	5125	\$328,000
12-Inch Pipe	CIPP	\$87	614	\$53,418
42-Inch Pipe	CIPP	\$385	7,488	\$2,882,880
12-Inch Pipe	Replacement	\$585	1,675	\$979,875
15-Inch Pipe	Replacement	\$585	4,519	\$2,643,615
21-Inch Pipe	Replacement	\$1,080	3,163	\$3,416,040
42-Inch Pipe	CCTV	\$5	7,488	\$37,440
Open Sluice Gates (each)		\$1,000	4	\$4,000
Manholes(each)	Rehab	\$3,719	264	\$981,816
Manholes(each)	Replacement	\$3,719	56	\$208,264
Subtotal				\$15,269,453
Eng. Design, Const Mgt/Insp, Admin, Post Eng. Svcs & Cont. (42%)				\$6,413,170
2008 Total Estimated Cost				\$21,680,000
2009 Total Estimated Cost				\$23,200,000
2010 Total Estimated Cost				\$24,820,000
2011 Total Estimated Cost				\$26,560,000
2012 Total Estimated Cost				\$28,420,000
2013 Total Estimated Cost				\$30,410,000
2014 Total Estimated Cost				\$32,540,000
2015 Total Estimated Cost				\$34,820,000
2016 Total Estimated Cost				\$37,260,000
2017 Total Estimated Cost				\$39,870,000

3.0 5-YEAR IMPROVEMENTS

See Map 3.0 for a detailed map showing the locations of the following projects described on a sub-sewershed basis. The work described below is additive to the work required for a 2-year event.



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3.1 Barclay Street

No Required Improvements.

3.2 Bolton Hill

No Required Improvements.

3.3 Greenmount Avenue

For the 5-year storm, overflows occur in flow meter basin JF04. The main cause of the overflows is a reach of 8-inch pipe between two reaches of 10 and 12-inch diameter pipe. It is recommended to increase the diameter of this 360 foot stretch from 8-inches to 12-inches between MHs S43UU_009MH and S43UU_030MH located between East 28th Street and Kennedy Avenue. The cost to complete this proposed work is presented in Table 3.3A.

TABLE 3.3A				
5-Year Greenmount Avenue Improvements (Pipe Replacement Option)				
Diameter	Rehab Method	Unit Cost	Quantity (LF)	Cost
12-Inch Pipe	Replace	\$585	360	\$210,600
Manholes(each)	Replace	\$3,719	6	\$22,314
Subtotal				\$232,914
Eng. Design, Const Mgt/Insp, Admin, Post Eng. Svcs & Cont. (42%)				\$97,824
2008 Total Estimated Cost				\$330,000
2009 Total Estimated Cost				\$350,000
2010 Total Estimated Cost				\$370,000
2011 Total Estimated Cost				\$400,000
2012 Total Estimated Cost				\$430,000
2013 Total Estimated Cost				\$460,000
2014 Total Estimated Cost				\$490,000
2015 Total Estimated Cost				\$520,000
2016 Total Estimated Cost				\$560,000
2017 Total Estimated Cost				\$600,000

In addition to the costs above, not removing the excessive inflow costs an additional \$600 per 5-year storm event and an additional \$54,000 per year in for convey and treat costs in 2008 dollars due to the extra infiltration. With the new Greenmount Interceptor completed under SC 833R, flows now bypass the Lower Jones Falls Interceptor and go directly into the High Level Interceptor. The Jones Falls hydraulic model can not predict what will happen downstream in the High Level Interceptor, but should the High Level require flow reduction from this area to minimize the chance of an overflow, I&I reduction can be completed instead of the pipe size increase. It is recommended to CIPP



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line all the pipes and rehabilitate all manholes beginning at MH S43SS_007MH, located in Aisquith Street, near Montpellier Street, and include all the pipes and manholes upstream that were not rehabilitated as part of the Paragraph 8 project, SC 820.

By completing this I&I reduction project, the estimated dry weather infiltration reduces from 250,000 gpd to 150,000 gpd and the 5-year storm RDII volume reduces from 1.2 MG to 0.8 MG. The costs to complete this proposed work is presented in Table 3.3B.

TABLE 3.3B				
5-Year Greenmount Avenue Improvements (I&I Removal Option)				
Diameter	Rehab Method	Unit Cost	Quantity (LF)	Cost
8-Inch Pipe	CIPP	\$45	29,123	\$1,310,535
10-Inch Pipe	CIPP	\$64	1,489	\$95,296
Manholes(each)	Rehab	\$3,719	188	\$699,172
Subtotal				\$2,105,003
Eng. Design, Const Mgt/Insp, Admin, Post Eng. Svcs & Cont. (42%)				\$884,101
2008 Total Estimated Cost				\$2,990,000
2009 Total Estimated Cost				\$3,200,000
2010 Total Estimated Cost				\$3,420,000
2011 Total Estimated Cost				\$3,660,000
2012 Total Estimated Cost				\$3,920,000
2013 Total Estimated Cost				\$4,190,000
2014 Total Estimated Cost				\$4,480,000
2015 Total Estimated Cost				\$4,790,000
2016 Total Estimated Cost				\$5,130,000
2017 Total Estimated Cost				\$5,490,000

3.4 Hampden Avenue

Flow meter basins JF18, JF19, and JF20, in the upper eastern portion of the Hampden Avenue sub-sewershed have elevated RDII rates that contribute to overflows for a 5-year storm event. These areas also have a high concentration of deteriorated pipe based on CCTV inspection. Therefore, it is recommended to complete a comprehensive I&I removal project beginning at MH S35WW_019MH on East 31st Street and CIPP line all the pipes and rehabilitate all the manholes upstream from this manhole.

By completing this I&I reduction project, the estimated dry weather infiltration reduces from 458,000 gpd to 275,000 gpd, for a yearly convey and treat cost savings of \$100,000. The 5-year storm RDII volume reduces from 1.9 MG to 1.1 MG for a convey and treat savings of \$1,200 per storm event. The cost to complete this proposed work is presented in Table 3.4.



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TABLE 3.4				
5-Year Hampden Avenue Improvements				
Diameter	Rehab Method	Unit Cost	Quantity (LF)	Cost
8-Inch Pipe	CIPP	\$45	72,640	\$3,268,800
10-Inch Pipe	CIPP	\$64	3,274	\$209,536
12-Inch Pipe	CIPP	\$87	4,268	\$371,316
15-Inch Pipe	CIPP	\$87	2,417	\$210,279
18-Inch Pipe	CIPP	\$124	756	\$93,744
Manholes(each)	Rehab	\$3,719	427	\$1,588,013
Subtotal				\$5,741,688
Eng. Design, Const Mgt/Insp, Admin, Post Eng. Svcs & Cont. (42%)				\$2,411,509
2008 Total Estimated Cost				\$8,150,000
2009 Total Estimated Cost				\$8,720,000
2010 Total Estimated Cost				\$9,330,000
2011 Total Estimated Cost				\$9,980,000
2012 Total Estimated Cost				\$10,680,000
2013 Total Estimated Cost				\$11,430,000
2014 Total Estimated Cost				\$12,230,000
2015 Total Estimated Cost				\$13,090,000
2016 Total Estimated Cost				\$14,010,000
2017 Total Estimated Cost				\$14,990,000

Rather than implementing an I&I removal program, an option is to parallel approximately 5,000 feet of 20, 21, and 24-inch pipe with an 18-inch pipe at an estimated cost of \$7.8 million in 2008 dollars. However, the passed flow leads to required improvements in the Lower Jones Falls at a cost far greater than the difference of \$350,000 between the I&I removal option and the convey and treat option as discussed in Section 3.5.

Another alternative is to construct a wet weather pumping station similar to the pumping station built in the Stony Run basin. The station would be located near the intersections of West 27th Street and Cresmont Avenue and would pump into the recently abandoned 36" diameter force main located 300 feet away. The pumping station would need to have a 15 MGD capacity and be configured to completely block all flow from proceeding downstream. The 2008 estimated cost for this pumping station is \$14.2 million. Due to the additional construction cost, this option has been dropped from consideration.

3.5 Lower Jones Falls

It is recommended to implement a comprehensive I&I removal project to CIPP line and rehabilitate all of the sewers within the JF33, JF34, and JF35 flow meter basins not previously lined as part of Paragraph 8 projects. This will reduce the average daily



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infiltration from 575,000 gpd to 345,000 gpd for a convey and treat annual cost savings of \$125,000. The 5-year storm RDII will be reduced from 1.95 MG to 1.03 MG for a per storm savings of \$1,400. The costs for the 5-year improvements required for the JF33, JF34, and JF35 areas are presented in Table 3.5

TABLE 3.5				
5-Year Lower Jones Falls Improvements				
Diameter	Rehab Method	Unit Cost	Quantity (LF)	Cost
8-Inch Pipe	CIPP	\$45	66,200	\$2,979,000
10-Inch Pipe	CIPP	\$64	4,614	\$295,296
12-Inch Pipe	CIPP	\$87	2,363	\$205,581
15-Inch Pipe	CIPP	\$87	175	\$15,225
Manholes(each)	Rehab	\$3,719	471	\$1,751,649
Subtotal				\$5,246,751
Eng. Design, Const Mgt/Insp, Admin, Post Eng. Svcs & Cont. (42%)				\$2,203,635
2008 Total Estimated Cost				\$7,450,000
2009 Total Estimated Cost				\$7,970,000
2010 Total Estimated Cost				\$8,530,000
2011 Total Estimated Cost				\$9,130,000
2012 Total Estimated Cost				\$9,770,000
2013 Total Estimated Cost				\$10,450,000
2014 Total Estimated Cost				\$11,180,000
2015 Total Estimated Cost				\$11,960,000
2016 Total Estimated Cost				\$12,800,000
2017 Total Estimated Cost				\$13,700,000

To convey and treat the flows rather than implement an I&I removal program, a 1,400 foot reach of new 15-inch pipe is required in the JF33/JF35 flow meter basins. In addition, to convey the flow through the Lower Jones Falls Interceptor, a parallel 4,700 foot long, 60-inch diameter interceptor would have to be constructed. The 60-inch line is also required to convey flows from the convey and treat option in the Hampden Avenue basin as discussed in Section 3.4. The estimated 2008 fully loaded costs for the improvements to convey and treat the 5 year, 24 hour event, including the extra volume of wastewater conveyed is estimated to be \$53.4 million. The combined I&I removal costs for both the Lower Jones Falls and Hampden Avenue areas is estimated to be \$15.6 million in 2008 dollars. An option to the 60-inch relief sewer is to construct both pumping stations as discussed in Sections 3.4 and 3.6 (Hampden and Maryland Avenue) at an estimated cost of \$32.1 million. Due to the high construction costs, these options have been dropped from consideration.



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3.6 Maryland Avenue

Following the I&I reduction required for the 2-year storm event, there are still SSOs in the Maryland Avenue sub-sewershed for a 5-year event. Therefore, pipe sizes must be increased to convey the flow without an overflow. The reach of 10-inch sewer beginning at MH S33GG_088MH at the intersection of Maryland Avenue and Oliver Street and going west 750 feet to MH S33GG_002MH needs to be upgraded to a 15-inch pipe. The reach of 12-inch pipe beginning at MH S33GG_022MH at the intersection of Mt. Royal Avenue and Morton Street and extending 420 feet to the east to MH S35GG_010MH needs to be upgraded to a 15-inch pipe as well.

For the 2-year storm event, it was required to increase a reach of pipe from 8-inches to 12-inches on Preston Street. However, for a 5-year event, it is required to increase the pipes along this reach to an 18-inch pipe, along with additional pipes upstream and downstream. The 1,110 foot stretch of pipe between MHs S31EE_022MH and S31CC_003MH on Preston Street needs to be upgraded to an 18-inch pipe from 8, 10, and 12-inch pipes. While a 15-inch diameter pipe will convey the flow without an overflow, it is recommended to install an 18-inch pipe. While there is slight price difference between 15 and 18-inch pipe, 18-inch pipe provides protection beyond the 20-year event. Velocities are sufficient to provide self cleaning in an 18-inch pipe, so there should not be an increased burden on maintenance. The estimated costs for construction are presented in Table 3.6.

TABLE 3.6				
5-Year Maryland Avenue Improvements				
Diameter	Rehab Method	Unit Cost	Quantity (LF)	Cost
15-Inch Pipe	Replacement	\$585	1,170	\$684,450
18-Inch Pipe	Replacement	\$1,080	1,110	\$1,198,800
Manholes(each)	Replacement	\$3,719	17	\$63,223
Subtotal				\$1,946,473
Eng. Design, Const Mgt/Insp, Admin, Post Eng. Svcs & Cont. (42%)				\$817,519
2008 Total Estimated Cost				\$2,760,000
2009 Total Estimated Cost				\$2,950,000
2010 Total Estimated Cost				\$3,160,000
2011 Total Estimated Cost				\$3,380,000
2012 Total Estimated Cost				\$3,620,000
2013 Total Estimated Cost				\$3,870,000
2014 Total Estimated Cost				\$4,140,000
2015 Total Estimated Cost				\$4,430,000
2016 Total Estimated Cost				\$4,740,000
2017 Total Estimated Cost				\$5,070,000



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To convey and treat all the flows in the Maryland Avenue basin rather than reduce I&I requires that the siphon be increased to 24 and 30-inches (from 18 and 24-inches), the reach of 18-inch pipe discussed above would be increased to 24-inches, and the Mount Royal reach increased to 21-inches. The 2008 estimated costs, including the increased flow volume conveyed and treated is estimated to be \$2.5 million in 2008 dollars. The increased flow volume also contributes to the necessity of the 60-inch relief interceptor and its associated \$53.4 million dollar cost as presented in Section 3.5.

Another option to increasing the size of the Maryland Avenue siphon and the 60-inch relief sewer is to install a wet weather pumping station similar to the one constructed for the Stony Run basin, located at the upstream side of the siphon. For a 5-year event, the pumping station would need to be able to handle 25 MGD and would pump the flows directly to the High Level Interceptor. It is estimated this would cost \$17.9 million in 2008 dollars. Due to the high construction cost, the convey and treat options have been eliminated from further consideration.

3.7 Stony Run

For the 5-year storm event it is required to slightly modify the Stony Run Pumping Station. As currently designed, once the pumping station is activated, 9 MGD passes the pumping station and is conveyed to the Lower Jones Falls. However, continued release at this rate causes overflows in the Lower Jones Falls without improvements. Therefore, it is recommended to modify the operation of the downstream sluice gate of the pumping station. Currently the sluice gate stays completely open, unless the station is inundated to a certain point, then it automatically drops to within 6 inches of the invert by existing equipment. It is recommended to adjust the programming of the station to instruct the sluice gate to close to within 3 inches of the invert once the pumping station is activated. This causes no adverse side effects upstream and the pumping station still has adequate capacity to convey the flows without overflows or even surcharging the incoming 60-inch diameter line.

There is a reach of sewer that overflows for the 5-year storm in the JF 26 flow meter basin. CCTV inspection records indicate that there are numerous sections of deteriorated pipes in this basin. Therefore it is recommended to CIPP line all the sewers and rehabilitate all the manholes upstream of MH S33QQ1008MH located near the western terminus of Winston Avenue. This will reduce the average daily infiltration from 261,000 gpd to 156,000 gpd for a convey and treat annual cost savings of \$57,000. The 5-year storm RDII will be reduced from 0.17 MG to 0.09 MG for a per storm savings of \$100. While these volumes do not decrease significantly, the peak flow from this flow meter basin decreases from almost 2.5 MGD to 0.5MGD.

The last recommended upgrade to convey the 5-year storm for the Stony Run sewershed is to upsize the 712 foot reach of 18-inch and 20-inch pipe from MH S29OO1015MH located north of Cold Spring Lane to MH S29MM1002MH located south of Cold Spring Lane, adjacent to Meadow Lane to a 24-inch diameter pipe. Table 3.7 presents the estimated costs for these proposed projects.



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TABLE 3.7 5-Year Stony Run Improvements				
Item	Rehab Method	Unit Cost	Quantity (LF)	Cost
8-Inch Pipe	CIPP	\$45	7,703	\$346,635
10-Inch Pipe	CIPP	\$64	1,124	\$71,936
24-Inch Pipe	Replacement	\$1,440	712	\$1,025,280
Manholes(each)	Rehab	\$3,719	48	\$178,512
Manholes(each)	Replacement	\$3,719	8	\$29,752
Stony Run PS Modifications	Reprogram	\$25,000	1	\$25,000
Subtotal				\$1,677,115
Eng. Design, Const Mgt/Insp, Admin, Post Eng. Svcs & Cont. (42%)				\$704,388
2008 Total Estimated Cost				\$2,380,000
2009 Total Estimated Cost				\$2,550,000
2010 Total Estimated Cost				\$2,730,000
2011 Total Estimated Cost				\$2,920,000
2012 Total Estimated Cost				\$3,120,000
2013 Total Estimated Cost				\$3,340,000
2014 Total Estimated Cost				\$3,570,000
2015 Total Estimated Cost				\$3,820,000
2016 Total Estimated Cost				\$4,090,000
2017 Total Estimated Cost				\$4,380,000

Instead of completing the inflow and infiltration abatement project in the JF26 flow meter basin, an option is to increase 800 feet of 10-inch pipe to 15-inch diameter pipe at a 2008 fully loaded cost of \$692,000. This is \$156,000 less expensive than the I&I removal, however, this is recovered in under three years in saved convey and treat costs.

3.8 Upper Jones Falls

There are SSOs for the 5-year storm spread through out the Upper Jones Falls sub-basin. I&I reduction programs can remove almost all of the overflows. To remove the projected SSOs for the 5-year storm event from JF43 and JF45 flow meter basins, it is proposed to rehabilitate the sewers and manholes to reduce RDII volumes. It is recommended to CIPP all the pipes and rehabilitate all of the manholes upstream of MH S19CC2011MH located south of the southern terminus of Newberry Street, to the west and to rehabilitate all the pipes and manholes from S15WW1007MH located in Northern Parkway, to the west. It is estimated this will reduce the average daily infiltration from 131,000 gpd to 67,000 gpd with an annual convey and treat cost savings of \$35,000. The RDII volumes will decrease from 0.93 MG to 0.55 MG for a 5-year storm event convey and treat savings of \$550 per storm event.



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For the 5-year storm event, there is an SSO located in the JF41 flow meter basin. However, this basin does not have elevated RDII or average daily infiltration rates and there are very few significantly deteriorated pipes, therefore an I&I reduction program most likely will not achieve great success. Therefore, the recommended option is to increase the size of pipe from MH S23QQ1013MH in Falls Road, 850 feet to the west to MH S21QQ1015MH from 8-inches to 15-inches. The costs associated with the rehabilitation projects in JF43 and JF45 and the pipe size increase in JF 41 are presented in Table 3.8.

TABLE 3.8				
5-Year Upper Jones Falls Improvements				
Diameter	Rehab Method	Unit Cost	Quantity (LF)	Cost
8-Inch Pipe	CIPP	\$45	11,479	\$516,555
10-Inch Pipe	CIPP	\$64	2,741	\$175,424
12-Inch Pipe	CIPP	\$87	350	\$30,450
15-Inch Pipe	Replace	\$585	850	\$497,250
Manholes(each)	Rehab	\$3,719	60	\$223,140
Manholes(each)	Replace	\$3,719	6	\$22,314
Subtotal				\$1,465,133
Eng. Design, Const Mgt/Insp, Admin, Post Eng. Svcs & Cont. (42%)				\$615,356
2008 Total Estimated Cost				\$2,080,000
2009 Total Estimated Cost				\$2,230,000
2010 Total Estimated Cost				\$2,390,000
2011 Total Estimated Cost				\$2,560,000
2012 Total Estimated Cost				\$2,740,000
2013 Total Estimated Cost				\$2,930,000
2014 Total Estimated Cost				\$3,140,000
2015 Total Estimated Cost				\$3,360,000
2016 Total Estimated Cost				\$3,600,000
2017 Total Estimated Cost				\$3,850,000

To convey and treat the wet weather infiltration from the JF43 and JF45 flow meter basins rather than reduce the infiltration will cost an estimated \$3.8 million in 2008 dollars. This is \$2.5 million more than the estimated \$1.4 million for I&I reduction. In addition if no I&I reduction is achieved in the flow basin upstream of the Jones Falls Pumping Station (Upper Jones Falls and Western Run), a 42-inch parallel interceptor would need to be constructed between the terminus of the 48-inch and 42-inch sewers and the beginning of the 60-inch interceptor, just north of the pumping station at an estimated cost of \$8.8 million in 2008 dollars. In addition, the Jones Falls Pumping Station would either have to increase capacity to 82 MGD or build a 27 MGD wet weather pumping station, similar to the Stony Run Station. An option to the increasing



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pumping is to build a 5 MG storage facility near the Jones Falls Pumping Station. The increased pumping option and the storage facility are estimated to be in the \$25 million dollar range in 2008 dollars. Due to the high cost of the convey and treat option, it has dropped from consideration.

3.9 Western Run

For the 5-year, 24 hour storm event, the majority of the overflows occur in the area east of Pimlico Road along Cross Country Boulevard. The two main reasons are the elevated flows from Baltimore County and the bottleneck caused at the end of the Western Run Interceptor where the 24-inch and 30-inch lines merge into a single 24-inch line. It is recommended to upsize approximately 6,630 feet of existing 20-inch, 21-inch and 24-inch pipe to 30-inch from MH S09CC2029MH to MH S19GG2071MH and to upsize the entrance structure from Western Run to the Upper Jones Falls Interceptor from 24-inches to 36-inches. Along with the 30-inch pipe it is recommended to increase the diameter of the 24-inch sluice gate at MH S11EE2097MH to 30-inches and to open the sluice gate between MHs S17EE2104MH and S17EE2023MH, constructed under SC 760.

Based on the I&I study report and Pipeline Assessment and Certification Program (PACP) ratings, there is high amount of ground water infiltration (GWI) and RDII in the flow meter basins JWR07, JFWR11, and JFWR19. An extensive rehabilitation program should be carried out in these basins. It is recommended to CIPP line all the pipes and rehabilitate all the manholes in these three basins. It is also recommended to upsize some pipe segments in the JFWR07 and JFWR24 basins to eliminate overflow. A detailed description on the size and location of the pipes in the above basins is as follows:

In JFWR07, reconstruct approximately 260 feet of existing 12-inch pipe to a steeper grade between MHs S04AA2002MH to S02AA2016MH located in Clarks Lane. Currently the reach of sewer is very flat with a drop connection. It is proposed to eliminate the drop connection and run the reach of sewer directly into the bottom of MH S02AA2016MH. A cursory look at existing utilities was completed and showed that no utilities were in the way; however a more detailed study would need to be completed.

In JFWR24, upsize approximately 990 feet of existing 12-inch pipe to 15-inch pipe between MHs S01AA2016MH to MH S01CC2004MH located in Bancroft Road. In addition it is recommended to replace 337 feet of existing 8-inch pipe with 10-inch pipe between MHs S02WW1007MH and S02YY1006MH located in Fords Lane.

After the I&I removal improvements, the average daily dry weather convey and treat volume will reduce from 438,000 gpd to 263,000 gpd for a yearly savings of \$101,000 in the three flow meter basins. The 5-year RDII volume will reduce from 4.27 MG to 2.08 MG for a per storm savings of \$3,500. The costs associated with all the improvements to convey the 5-year, 24 hour storm event are presented in Table 3.9.



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TABLE 3.9 5-Year Western Run Improvements				
Diameter	Rehab Method	Unit Cost	Quantity (LF)	Cost
8-Inch Pipe	CIPP	\$45	64,586	\$2,906,370
10-Inch Pipe	CIPP	\$64	7,551	\$483,264
12-Inch Pipe	CIPP	\$87	1,832	\$159,384
15-Inch Pipe	CIPP	\$87	125	\$10,875
10-Inch Pipe	Replacement	\$495	337	\$166,815
12-Inch Pipe	Replacement	\$585	260	\$152,100
15-Inch Pipe	Replacement	\$585	990	\$579,150
30-Inch Pipe	Replacement	\$1,530	6,630	\$10,143,900
36-Inch Pipe	Replacement	\$1,620	25	\$40,500
Manholes(each)	Rehab	\$3,719	352	\$1,309,088
Manholes(each)	Replacement	\$3,719	48	\$178,512
Subtotal				\$16,129,958
Eng. Design, Const Mgt/Insp, Admin, Post Eng. Svcs & Cont. (42%)				\$6,774,582
2008 Total Estimated Cost				\$22,900,000
2009 Total Estimated Cost				\$24,500,000
2010 Total Estimated Cost				\$26,220,000
2011 Total Estimated Cost				\$28,060,000
2012 Total Estimated Cost				\$30,020,000
2013 Total Estimated Cost				\$32,120,000
2014 Total Estimated Cost				\$34,370,000
2015 Total Estimated Cost				\$36,780,000
2016 Total Estimated Cost				\$39,350,000
2017 Total Estimated Cost				\$42,100,000

To convey and treat the flows in the Western Run basin without inflow reduction would involve further pipe size increases in the JFWR07 and JFWR24 basins. Within the JFWR07 basin, pipes would have to be increased to 21-inches from 10-inches. The dry weather velocities within a 21-inch pipe are well below 2 feet per second and have the potential to increase maintenance requirements. The 2008 fully loaded estimated cost to convey and treat, including the additional flow, is \$18.9 million. While less than the I&I reduction cost of \$22.9 million, convey and treating passes required improvements (estimated to cost approximately \$33 million) onto the Upper Jones Falls basin as described in Section 3.8.



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3.10 5-Year Summary

The combined cost estimate for all improvements recommended to convey the 5-year, 24 hour storm event in the Jones Falls Sewershed is presented in Table 3.10. The quantities and costs include the recommendations to convey the 2-year event, since those improvements are required to convey the 5-year event as well. The seven (2 and 5-year improvements) recommended I&I reduction projects are estimated to save the City approximately \$563,000 (2008 dollars) per year in treatment costs. The average cost to eliminate each gallon of estimated overflow is estimated to be \$2.88 in 2008 dollars, however, the cost to eliminate the overflows moving from the 2-year improvements to the 5-year improvements is estimated to be \$10.72 per gallon in 2008 dollars.

TABLE 3.10				
5-Year Jones Falls Improvements				
Diameter	Rehab Method	Unit Cost	Quantity (LF)	Cost
8-Inch Pipe	CIPP	\$45	250,977	\$11,293,965
10-Inch Pipe	CIPP	\$64	24,429	\$1,563,456
12-Inch Pipe	CIPP	\$87	9,427	\$820,149
15-Inch Pipe	CIPP	\$87	2,717	\$236,379
18-Inch Pipe	CIPP	\$124	756	\$93,744
42-Inch Pipe	CIPP	\$385	7,488	\$2,882,880
10-Inch Pipe	Replacement	\$495	337	\$166,815
12-Inch Pipe	Replacement	\$585	2,295	\$1,342,575
15-Inch Pipe	Replacement	\$585	7529	\$4,404,465
18-Inch Pipe	Replacement	\$1,080	1,110	\$1,198,800
21-Inch Pipe	Replacement	\$1,080	3,163	\$3,416,040
24-Inch Pipe	Replacement	\$1,440	712	\$1,025,280
30-Inch Pipe	Replacement	\$1,530	6,630	\$10,143,900
36-Inch Pipe	Replacement	\$1,620	25	\$40,500
Manholes(each)	Rehab	\$3,719	1622	\$6,032,218
Manholes(each)	Replacement	\$3,719	141	\$524,379
Stony Run PS Modifications	Reprogram	\$25,000	1	\$25,000
42-Inch Pipe	CCTV	\$5	7,488	\$37,440
Open Sluice Gates (each)		\$1,000	4	\$4,000
18-Inch Siphon	Clean	\$300	525	\$157,500
24-Inch Siphon	Clean	\$300	250	\$75,000
50-Inch Pipe (1,924 LF)	Heavy Cleaning	\$500/ton	850	\$425,000
56-Inch Pipe (370 LF)	Heavy Cleaning	\$500/ton	200	\$100,000
64-Inch Pipe (2,475 LF)	Heavy Cleaning	\$500/ton	1,800	\$900,000
75-Inch Pipe (1,534 LF)	Heavy Cleaning	\$500/ton	1,600	\$800,000



TABLE 3.10				
5-Year Jones Falls Improvements				
Diameter	Rehab Method	Unit Cost	Quantity (LF)	Cost
Subtotal				\$47,709,485
Eng. Design, Const Mgt/Insp, Admin, Post Eng. Svcs & Cont. (42%)				\$20,037,984
2008 Total Estimated Cost				\$67,750,000
2009 Total Estimated Cost				\$72,490,000
2010 Total Estimated Cost				\$77,560,000
2011 Total Estimated Cost				\$82,990,000
2012 Total Estimated Cost				\$88,800,000
2013 Total Estimated Cost				\$95,020,000
2014 Total Estimated Cost				\$101,670,000
2015 Total Estimated Cost				\$108,790,000
2016 Total Estimated Cost				\$116,410,000
2017 Total Estimated Cost				\$124,560,000

The convey and treat cost estimate (no inflow and infiltration reduction) is estimated to be \$152.6 million for the 60-inch relief sewer option or \$131.3 million for the Hampden and Maryland Avenue pumping station option in fully loaded 2008 dollars. This is double the cost of I&I reduction alternatives. Except for a few select areas, convey and treat is not a cost effective option in the Jones Falls. The increased costs, community disturbance, and operation and maintenance requirements make convey and treat an undesirable option and will not be considered for further storm evaluations except for a small, site specific location (similar to the Section 3.8, Upper Jones Falls scenario of flow meter basin JF41).

4.0 10-YEAR IMPROVEMENTS

See Map 4.0 for a detailed map showing the locations of the following projects described on a sub-sewershed basis. The work described below is additive to the work required for the 2 and 5-year event.

4.1 Barclay Street

It is recommended to implement a comprehensive I&I reduction program in the upper reaches of the Barclay Street sub-sewershed to remove SSOs for the 10-year storm event. The RDII rates, average daily infiltration, and CCTV results all indicate that an I&I removal program has great potential to remove the SSOs. It is recommend to completely rehabilitate the sewer system beginning at MH S33QQ_023MH located in East 25th Street, upstream and beginning at MH S35MM_024MH located in East 21 Street, upstream. The daily convey and treat volumes will reduce from 630,000 gpd to 380,000 gpd for a cost savings of \$136,000 annually. The 10-year storm event convey and treat



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volumes will reduce from 1.6 MG to 0.5 MG for a convey and treat savings of \$1,600 per storm event. The costs associated with the recommendation are presented in Table 4.1.

TABLE 4.1				
10-Year Barclay Street Improvements				
Diameter	Rehab Method	Unit Cost	Quantity (LF)	Cost
8-Inch Pipe	CIPP	\$45	30,718	\$1,382,310
10-Inch Pipe	CIPP	\$64	2,766	\$177,024
12-Inch Pipe	CIPP	\$87	644	\$56,028
15-Inch Pipe	CIPP	\$87	1,723	\$149,901
18-Inch Pipe	CIPP	\$124	360	\$44,640
Manholes(each)	Rehab	\$3,719	233	\$866,527
Subtotal				\$2,676,430
Eng. Design, Const Mgt/Insp, Admin, Post Eng. Svcs & Cont. (42%)				\$1,124,101
2008 Total Estimated Cost				\$3,800,000
2009 Total Estimated Cost				\$4,070,000
2010 Total Estimated Cost				\$4,350,000
2011 Total Estimated Cost				\$4,650,000
2012 Total Estimated Cost				\$4,980,000
2013 Total Estimated Cost				\$5,330,000
2014 Total Estimated Cost				\$5,700,000
2015 Total Estimated Cost				\$6,100,000
2016 Total Estimated Cost				\$6,530,000
2017 Total Estimated Cost				\$6,990,000

4.2 Bolton Hill

To eliminate the SSOs in the Bolton Hill area for the 10-year storm, it is recommended to implement an I&I reduction program. Flow meter basins JF13, JF14, and JF15, all in the western half of the Bolton Hill sub-sewershed, have elevated RDII rates based on the flow metering. These results are corroborated by CCTV data and there are a significant number of pipes with defects (cracks, open joints, fractures) that can lead to increased I&I rates. Based on these facts it is recommended to complete an extensive I&I reduction program in this area and a small part of JF12 to remove the potential for SSOs for the 10-year event. All of the sewers and manholes should be CIPP lined and rehabilitated beginning at MH S29II_004MH on McMechen Street to the west.

By completing this I&I reduction project, the estimated dry weather infiltration reduces from 756,000 gpd to 454,000 gpd, for a yearly convey and treat cost savings of \$164,000. The 10-year storm RDII volume reduces from 1.82 MG to 0.88 MG for a convey and



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treat savings of \$1,400 per storm event. The costs to complete this proposed work is presented in Table 4.2.

TABLE 4.2				
10-Year Bolton Hill Improvements				
Diameter	Rehab Method	Unit Cost	Quantity (LF)	Cost
8-Inch Pipe	CIPP	\$45	75,615	\$3,402,675
10-Inch Pipe	CIPP	\$64	5,153	\$329,792
12-Inch Pipe	CIPP	\$87	2,173	\$189,051
15-Inch Pipe	CIPP	\$87	1,550	\$134,850
21-Inch Pipe	CIPP	\$124	1,033	\$128,092
24-Inch Pipe	CIPP	\$169	990	\$167,310
Manholes(each)	Rehab	\$3,719	565	\$2,101,235
Subtotal				\$6,453,005
Eng. Design, Const Mgt/Insp, Admin, Post Eng. Svcs & Cont. (42%)				\$2,710,262
2008 Total Estimated Cost				\$9,160,000
2009 Total Estimated Cost				\$9,800,000
2010 Total Estimated Cost				\$10,490,000
2011 Total Estimated Cost				\$11,220,000
2012 Total Estimated Cost				\$12,010,000
2013 Total Estimated Cost				\$12,850,000
2014 Total Estimated Cost				\$13,750,000
2015 Total Estimated Cost				\$14,710,000
2016 Total Estimated Cost				\$15,740,000
2017 Total Estimated Cost				\$16,840,000

4.3 Greenmount Avenue

For the 10-year, 24 hour storm event, there are overflows in flow meter basin JF04. To remove potential overflows, it is recommended to upsize approximately 633 feet of existing 10-inch pipe to 12-inch from MH S43SS_025MH to MH S43SS_015MH along an alley northeast of the intersection of Polk Street and Homestead Street. However, if an I&I abatement program is selected as described in Section 3.3, no additional work is required. In addition to the improvements made for the 5-year, 24 hour storm event, the costs associated with all the improvements to convey the 10-year, 24 hour storm event are presented in Table 4.3.



TABLE 4.3				
10-Year Greenmount Avenue Improvements				
Diameter	Rehab Method	Unit Cost	Quantity (LF)	Cost
15-Inch Pipe	Replacement	\$585	633	\$370,305
Manholes(each)	Replacement	\$3,719	4	\$14,876
Subtotal				\$385,181
Eng. Design, Const Mgt/Insp, Admin, Post Eng. Svcs & Cont. (42%)				\$161,776
2008 Total Estimated Cost				\$550,000
2009 Total Estimated Cost				\$590,000
2010 Total Estimated Cost				\$630,000
2011 Total Estimated Cost				\$670,000
2012 Total Estimated Cost				\$720,000
2013 Total Estimated Cost				\$770,000
2014 Total Estimated Cost				\$820,000
2015 Total Estimated Cost				\$880,000
2016 Total Estimated Cost				\$940,000
2017 Total Estimated Cost				\$1,010,000

4.4 Hampden Avenue

To eliminate the SSOs in the Hampden Avenue area for the 10-year storm, it is recommended to implement an I&I reduction program. According to the CCTV inspection, there are deteriorated sewers and the RDII rates are elevated, thus leading to the recommendation to rehabilitate the sewer infrastructure. It is recommended to CIPP line all the sewers and rehabilitate all the manholes beginning at MH S33UU_026MH, just north of Wyman Park Drive and lining all of the sewers upstream not previously rehabilitated for the 5-year storm. The average daily dry weather convey and treat volume will reduce from 76,000 gpd to 46,000 gpd for a yearly savings of \$16,000. The 10-year RDII volume will reduce from 0.58 MG to 0.2 MG for a per storm savings of \$570. The costs associated with this upgrade are presented in Table 4.4.

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TABLE 4.4				
10-Year Hampden Avenue Improvements				
Diameter	Rehab Method	Unit Cost	Quantity (LF)	Cost
8-Inch Pipe	CIPP	\$45	1,895	\$85,275
10-Inch Pipe	CIPP	\$64	633	\$40,512
12-Inch Pipe	CIPP	\$87	1012	\$88,044
18-Inch Pipe	CIPP	\$124	467	\$57,908
20-Inch Pipe	CIPP	\$124	755	\$93,620
24-Inch Pipe	CIPP	\$169	1,117	\$188,773
Manholes(each)	Rehab	\$3,719	32	\$119,008
Subtotal				\$673,140
Eng. Design, Const Mgt/Insp, Admin, Post Eng. Svcs & Cont. (42%)				\$282,719
2008 Total Estimated Cost				\$960,000
2009 Total Estimated Cost				\$1,030,000
2010 Total Estimated Cost				\$1,100,000
2011 Total Estimated Cost				\$1,180,000
2012 Total Estimated Cost				\$1,260,000
2013 Total Estimated Cost				\$1,350,000
2014 Total Estimated Cost				\$1,440,000
2015 Total Estimated Cost				\$1,540,000
2016 Total Estimated Cost				\$1,650,000
2017 Total Estimated Cost				\$1,770,000

4.5 Lower Jones Falls

To convey the flow in the Lower Jones Falls without an overflow for the 10-year storm event, two projects were identified. To eliminate the SSOs in the JF32 flow meter basin for the 10-year storm, it is recommended to implement an I&I reduction program. According to the CCTV inspection, there are deteriorated sewers and the RDII rates are elevated, thus leading to the recommendation to rehabilitate the sewer infrastructure. It is recommended to CIPP line all the sewers and rehabilitate all the manholes beginning at MH S27WW_086MH located in Falls Road, and continuing upstream. The average daily dry weather convey and treat volume will reduce from 168,000 gpd to 109,000 gpd for a yearly savings of \$32,000. The 10-year RDII volume will reduce from 0.8 MG to 0.45 MG for a per storm savings of \$522.

In the flow meter basin JF35, there is a 10-inch pipe that runs underneath a Pepsi bottling plant. This pipe is a constriction point and causes an overflow at the 10-year storm level. It is recommended to install a new 820 foot long, 15-inch line in Buena Vista Avenue from MH S23EE1009MH to MH S23CC1042MH to by-pass the Pepsi building. The existing 10-inch line running underneath the plant will need to remain active to service the building. In addition the existing 10-inch and 12-inch sewer in Union Avenue



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between MHs S23CC1042MH and S23CC1027MH will need to be upgraded to a 15-inch pipe. The costs associated with these upgrades are presented in Table 4.5.

TABLE 4.5				
10-Year Lower Jones Falls Improvements				
Diameter	Rehab Method	Unit Cost	Quantity (LF)	Cost
8-Inch Pipe	CIPP	\$45	18,406	\$828,270
10-Inch Pipe	CIPP	\$64	1,470	\$94,080
12-Inch Pipe	CIPP	\$87	840	\$73,080
15-Inch Pipe	Replacement	\$585	1352	\$790,920
Manholes(each)	Rehab	\$3,719	130	\$483,470
Manholes(each)	Replacement	\$3,719	6	\$22,314
Subtotal				\$2,292,134
Eng. Design, Const Mgt/Insp, Admin, Post Eng. Svcs & Cont. (42%)				\$962,696
2008 Total Estimated Cost				\$3,250,000
2009 Total Estimated Cost				\$3,480,000
2010 Total Estimated Cost				\$3,720,000
2011 Total Estimated Cost				\$3,980,000
2012 Total Estimated Cost				\$4,260,000
2013 Total Estimated Cost				\$4,560,000
2014 Total Estimated Cost				\$4,880,000
2015 Total Estimated Cost				\$5,220,000
2016 Total Estimated Cost				\$5,590,000
2017 Total Estimated Cost				\$5,980,000

4.6 Maryland Avenue

In order to convey the 10-year storm event in the Maryland Avenue sub-basin, the existing triple barrel 18-inch and single pipe 24-inch diameter siphon must be upsized. A detailed hydraulic study (beyond the scope of this report) will be required to design the exact configuration, but the siphon will be required to convey minimum daily flows of 0.6 MGD to peak rain event flows of 37 MGD. For this report, it was decided to maintain the existing configuration and simply increase the diameter of the pipes. The existing 18-inch triple barrel is increased to 24-inches and the single 24-inch pipe is increased to 36-inches in diameter. The costs associate with this pipe size increase is presented in Table 4.6.



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TABLE 4.6				
10-Year Maryland Avenue Improvements				
Diameter	Rehab Method	Unit Cost	Quantity (LF)	Cost
24" Siphon	Replacement	\$1,440	522	\$751,680
36" Siphon	Replacement	\$1,620	250	\$405,000
Subtotal				\$1,156,680
Eng. Design, Const Mgt/Insp, Admin, Post Eng. Svcs & Cont. (42%)				\$485,806
2008 Total Estimated Cost				\$1,640,000
2009 Total Estimated Cost				\$1,750,000
2010 Total Estimated Cost				\$1,870,000
2011 Total Estimated Cost				\$2,000,000
2012 Total Estimated Cost				\$2,140,000
2013 Total Estimated Cost				\$2,290,000
2014 Total Estimated Cost				\$2,450,000
2015 Total Estimated Cost				\$2,620,000
2016 Total Estimated Cost				\$2,800,000
2017 Total Estimated Cost				\$3,000,000

It should be noted that by lining all the sewers and rehabilitating all of the manholes as identified in Section 2.6 will dramatically modify the characteristics of the basin. These changes include capture coefficients, basin slope, and basin width. While an attempt has been made to simulate those changes, it is suggested to complete upstream system improvements first. Following this, flow monitoring of the basin should be conducted to recalibrate the model to better predict the size of the siphon improvements.

4.7 Stony Run

The optional I&I removal program discussed in Section 2.7 for the 2-year storm now makes financial sense to implement. Therefore it is recommended to CIPP line all the sewers and rehabilitate all the manholes upstream of MH S31GG1003MH, located in Underwood Road. In addition it is recommended to CIPP line all the sewers and rehabilitate all the manholes upstream of MH S33SS1003MH, located between Homewood Avenue and Notre Dame Lane. The average daily dry weather convey and treat volume will reduce from 470,000 gpd to 282,000 gpd for a yearly savings of \$102,000. The 10-year RDII volume will reduce from 2.5 MG to 1.3 MG for a per storm savings of \$1,800. The costs associated with this upgrade are presented in Table 4.7.



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TABLE 4.7				
10-Year Stony Run Improvements				
Item	Rehab Method	Unit Cost	Quantity (LF)	Cost
8-Inch Pipe	CIPP	\$45	68,162	\$3,067,290
10-Inch Pipe	CIPP	\$64	4,195	\$268,480
12-Inch Pipe	CIPP	\$87	914	\$79,518
Manholes(each)	Rehab	\$3,719	421	\$1,565,699
Subtotal				\$4,980,987
Eng. Design, Const Mgt/Insp, Admin, Post Eng. Svcs & Cont. (42%)				\$2,092,015
2008 Total Estimated Cost				\$7,070,000
2009 Total Estimated Cost				\$7,560,000
2010 Total Estimated Cost				\$8,090,000
2011 Total Estimated Cost				\$8,660,000
2012 Total Estimated Cost				\$9,270,000
2013 Total Estimated Cost				\$9,920,000
2014 Total Estimated Cost				\$10,610,000
2015 Total Estimated Cost				\$11,350,000
2016 Total Estimated Cost				\$12,140,000
2017 Total Estimated Cost				\$12,990,000

4.8 Upper Jones Falls

In order to convey the 10-year storm event in the Upper Jones Falls, two storage tanks are recommended. The construction required to avoid storage tanks would extend from the City/County border all the way to the Jones Falls Pump Station and from the Falls Road Siphon to the High Level Interceptor, which may not be able to handle the drastic increase in flow. The first recommended tank is located near the City/County line and the second tank is located at the Jones Falls Pumping Station. The peak flow coming from Western Run and Baltimore County overwhelms the Upper Jones Falls collection system. The proposed storage tank near the City/County boundary needs to be able to hold 1.25 MG. The tank can be sited anywhere along the upper Upper Jones Falls Interceptor (between the City/County line to Mount Washington), but needs to keep the flow depths below elevation 186.5 at MH S19EE2022MH. At the City/County boundary near the permanent flow metering station that measures flow entering from the County, there are about 2 acres of land owned by the City of Baltimore. This land, however, is in a residential neighborhood. In Mount Washington there are several large parking lots that the tank could be sited under, however the City would have to obtain the land. The main purpose of this tank is to offset the incoming peak flows from Western Run and the County. The downstream collection system can handle the volume from each contributing area; however it can not handle the combined peak flow rates. What the tank accomplishes is removing the peak flow from either area, depending on where it is located, and allows the other peak flow to pass through.



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The proposed storage facility near the Jones Falls Pumping Station needs to be 3.75 MG in capacity. The pumping station is currently configured so that when incoming flow rates exceed the pump station capacity, the flows are bypassed to the Lower Jones Falls. However, at the 10-year rainfall event, these bypassed flows exceed the capacity of the Lower Jones Falls Interceptor and cause downstream overflows. Rather than the bypassed flow proceeding downstream, it should be diverted into a storage facility, to be pumped back into the system once the storm and peak flows have passed. While an attempt was made to locate the storage facilities on City owned property, additional land may have to be obtained. The estimated cost of \$6/gallon of storage contains the cost for potential land acquisitions. The estimated costs for both storage facilities are in Table 4.8A.

TABLE 4.8A				
10-Year Upper Jones Falls Improvements (Storage Facilities)				
Diameter	Rehab Method	Unit Cost	Quantity (LF)	Cost
1.25 MG Storage Tank Near WR	New	\$6/gallon	1.25 MG	\$7,500,000
3.75 MG Storage Tank Near JFPS	New	\$6/gallon	3.75 MG	\$22,500,000
Subtotal				\$30,000,000
Eng. Design, Const Mgt/Insp, Admin, Post Eng. Svcs & Cont. (42%)				\$12,600,000
2008 Total Estimated Cost				\$42,600,000
2009 Total Estimated Cost				\$45,580,000
2010 Total Estimated Cost				\$48,770,000
2011 Total Estimated Cost				\$52,180,000
2012 Total Estimated Cost				\$55,830,000
2013 Total Estimated Cost				\$59,740,000
2014 Total Estimated Cost				\$63,920,000
2015 Total Estimated Cost				\$68,390,000
2016 Total Estimated Cost				\$73,180,000
2017 Total Estimated Cost				\$78,300,000

There are several complexities to an offline storage facility that need to be addressed. They can be very large, difficult to site, receive strong public resistance, require pumping and its associated costs and maintenance, need odor control facilities, and require additional operation and maintenance costs. However, they have the benefit of providing the capability for a smaller collection system (which reduces O&M costs), reduce downstream improvements, and help reduce peak flows to the treatment plants to help keep them in compliance of their discharge permits.

It should be noted that by lining all the sewers and rehabilitating all of the manholes previously identified will dramatically modify the hydraulic characteristics of the Jones Falls system. These changes include capture coefficients, basin slope, and basin width. While an attempt has been made to simulate those changes, it is suggested to complete



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the other system improvements first. Then, reflow monitor the basin to recalibrate the hydraulic model to better predict the size and location of the potential storage facilities.

Another alternative to offline storage is inline storage. This method reduces some of the complexities of offline storage and has no pumping costs. In the Upper Jones Falls for example, the reach of pipe from the City/County line down to the start of the new 48-inch sewer completed under SC 772 can be expanded to a 10-foot wide by 9-foot tall cunette shaped pipe (large arch shaped pipe with a smaller channel in the bottom to convey dry weather flow). A pipe of those dimensions provides a million gallons of inline storage. An inline storage pipe helps to reduce the velocities of the flow and helps offset peak flows from various sources. However, an inline storage pipe in the upper Jones Falls area does pass flow downstream that needs to be stored at the Jones Falls Pumping Station facility, increasing its proposed size to 4 MG.

An alternative to the storage facility near the Jones Falls Pumping Station is to upgrade the Jones Falls Pumping Station to 75 MGD from its current 55 MGD capacity or to construct a 20 MGD wet weather pumping facility. Along with this upgrade, it will be required to reactive the abandoned 36-inch forcemain removed from service under Paragraph 8 Project SC 800. Prior to reactivation, the line will need to be internally inspected, cleaned, and complete any repairs if they are required. It is estimated that a wet weather pumping station would have similar costs of the Stony Run Pumping Station of around \$15.0 million.

In addition to the above improvements, it is recommended to abate I&I in the JF38 flow meter basin to remove overflows. It is proposed to CIPP all the pipes and rehabilitate all of the manholes beginning from MH S17KK1009MH on Cold Spring Road, near Greenspring Avenue, and continuing upstream. With the I&I removal program, the average daily infiltration is reduced from 197,000 gpd to 118,000 gpd for an annual convey and treat cost savings of \$45,000. The RDII volume decreases from 1.33 MG to 0.73 MG for a 10-year storm convey and treat savings of \$950. The cost for the improvements to the JF38 area is presented in Table 4.8B.



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TABLE 4.8B				
10-Year Upper Jones Falls Improvements (JF38)				
Diameter	Rehab Method	Unit Cost	Quantity (LF)	Cost
8-Inch Pipe	CIPP	\$45	21,914	\$986,130
10-Inch Pipe	CIPP	\$64	715	\$45,760
12-Inch Pipe	CIPP	\$87	1280	\$111,360
15-Inch Pipe	CIPP	\$87	2059	\$179,133
18-Inch Pipe	CIPP	\$124	292	\$36,208
Manholes(each)	Rehab	\$3,719	145	\$539,255
Subtotal				\$1,897,846
Eng. Design, Const Mgt/Insp, Admin, Post Eng. Svcs & Cont. (42%)				\$797,095
2008 Total Estimated Cost				\$2,690,000
2009 Total Estimated Cost				\$2,880,000
2010 Total Estimated Cost				\$3,080,000
2011 Total Estimated Cost				\$3,300,000
2012 Total Estimated Cost				\$3,530,000
2013 Total Estimated Cost				\$3,780,000
2014 Total Estimated Cost				\$4,040,000
2015 Total Estimated Cost				\$4,320,000
2016 Total Estimated Cost				\$4,620,000
2017 Total Estimated Cost				\$4,940,000

4.9 Western Run

For the 10-year, 24 hour storm event, overflows occur at similar locations as described for the 5-year, 24 hour storm event. In addition to these locations there are overflows along the 20-inch line west of Pimlico Road, and in flow meter basins JFWR18, JFWR22, and JFWR33. It is recommended to CIPP line pipes and rehabilitate all the manholes in these three basins. In addition it is recommended to rehabilitate the sewer infrastructure in the upper portions of both JFWR17, upstream of MH S07EE2012MH in Greenspring Avenue, and JFWR14, upstream of MH S05II2021MH located in Greenspring Avenue. In addition, several pipe segments require upsizing throughout the Western Run basin, a detailed description of all the recommended improvements is as follows:

In JFWR07, it is recommended to upsize approximately 1,107 feet of existing 12-inch pipe to 15-inch pipe between MHs S02CC2013MH and S04AA2002MH along Clarks Lane. In addition, it is recommended to increase 1,055 feet of 10-inch pipe to 12-inch pipe between MHs S04CC2003MH and S04AA2002MH and between MHs S04AA2005MH and S04AA2002MH.



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In JFWR24, upsize approximately 4,116 feet of existing 8 and 10-inch pipe to 12-inch pipe upstream of MH S01AA2016MH to MH S04UU1006MH, from Bancroft Road to Fordleigh Road. In addition, it is recommended to construct a 140 foot long cross connection (21-inches in diameter) between the new 24-inch line constructed under SC 789 (MH S01EE2088MH) and the downstream end of JFWR24 (MH S01CC2004MH).

In JFWR19, upsize approximately 393 feet of existing 12-inch pipe to 15-inch pipe between MHs S07AA2017MH (Cross Country Boulevard) and S07YY1016MH (Glenn Avenue).

In JFWR11, upsize approximately 1,412 feet of existing 10-inch pipe to 12-inch pipe from MH S13EE2034MH to MH S13CC2021MH, east of Cross Country Boulevard south of Kelly Avenue.

After all these improvements, the average daily dry weather infiltration convey and treat volume will reduce from 311,000 gpd to 187,000 gpd for a yearly savings of \$72,000 in the areas identified for I&I reduction. The 10-year RDII volume will reduce from 4.17 MG to 1.98 MG for a per storm savings of \$3,500. The costs associated with all the improvements to convey the 10-year, 24 hour storm event are presented in Table 4.9.



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TABLE 4.9				
10-Year Western Run Improvements				
Diameter	Rehab Method	Unit Cost	Quantity (LF)	Cost
8-Inch Pipe	CIPP	\$45	41,739	\$1,878,255
10-Inch Pipe	CIPP	\$64	3,873	\$247,872
12-Inch Pipe	CIPP	\$87	1,105	\$96,135
15-Inch Pipe	CIPP	\$87	33	\$2,871
12-Inch Pipe	Replacement	\$585	6,584	\$3,851,640
15-Inch Pipe	Replacement	\$585	1,500	\$877,500
21-Inch Pipe	New	\$1,080	140	\$151,200
Manholes(each)	Rehab	\$3,719	228	\$847,932
Manholes(each)	Replacement	\$3,719	36	\$133,884
Subtotal				\$8,087,289
Eng. Design, Const Mgt/Insp, Admin, Post Eng. Svcs & Cont. (42%)				\$3,396,661
2008 Total Estimated Cost				\$11,480,000
2009 Total Estimated Cost				\$12,280,000
2010 Total Estimated Cost				\$13,140,000
2011 Total Estimated Cost				\$14,060,000
2012 Total Estimated Cost				\$15,040,000
2013 Total Estimated Cost				\$16,090,000
2014 Total Estimated Cost				\$17,220,000
2015 Total Estimated Cost				\$18,430,000
2016 Total Estimated Cost				\$19,720,000
2017 Total Estimated Cost				\$21,100,000

4.10 10-Year Summary

The combined cost estimate for all improvements recommended to convey the 10-year, 24 hour storm event in the Jones Falls Sewershed is presented in Table 4.10. The quantities and costs include the recommendations to convey the 2-year and 5-year event, since those improvements are required to convey the 10-year event as well. The fourteen (2, 5, and 10-year improvements) recommended I&I reduction projects are estimated to save the City approximately \$1,130,000 (2008 dollars) per year in treatment costs. The average cost to eliminate each gallon of estimated overflow is estimated to be \$4.71 in 2008 dollars; however, the cost to eliminate the overflows moving from the 5-year improvements to the 10-year improvements is estimated to be \$29.62 per gallon in 2008 dollars.



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TABLE 4.10 10-Year Jones Falls Improvements				
Diameter	Rehab Method	Unit Cost	Quantity (LF)	Cost
8-Inch Pipe	CIPP	\$45	509,426	\$22,924,170
10-Inch Pipe	CIPP	\$64	43,234	\$2,766,976
12-Inch Pipe	CIPP	\$87	17,395	\$1,513,365
15-Inch Pipe	CIPP	\$87	8,082	\$703,134
18-Inch Pipe	CIPP	\$124	1875	\$232,500
20-Inch Pipe	CIPP	\$124	755	\$93,620
21-Inch Pipe	CIPP	\$124	1,033	\$128,092
24-Inch Pipe	CIPP	\$169	2107	\$356,083
42-Inch Pipe	CIPP	\$385	7,488	\$2,882,880
10-Inch Pipe	Replacement	\$495	337	\$166,815
12-Inch Pipe	Replacement	\$585	8,879	\$5,194,215
15-Inch Pipe	Replacement	\$585	11014	\$6,443,190
18-Inch Pipe	Replacement	\$1,080	1,110	\$1,198,800
21-Inch Pipe	Replacement	\$1,080	3,303	\$3,567,240
24-Inch Pipe	Replacement	\$1,440	1234	\$1,776,960
30-Inch Pipe	Replacement	\$1,530	6,630	\$10,143,900
36-Inch Pipe	Replacement	\$1,620	275	\$445,500
Manholes(each)	Rehab	\$3,719	3376	\$12,555,344
Manholes(each)	Replacement	\$3,719	187	\$695,453
Stony Run PS Modifications	Reprogram	\$25,000	1	\$25,000
42-Inch Pipe	CCTV	\$5	7,488	\$37,440
Open Sluice Gates (each)		\$1,000	4	\$4,000
24" Siphon	Replacement	\$1,440	522	\$751,680
36" Siphon	Replacement	\$1,620	250	\$405,000
50-Inch Pipe (1,924 LF)	Heavy Cleaning	\$500/ton	850	\$425,000
56-Inch Pipe (370 LF)	Heavy Cleaning	\$500/ton	200	\$100,000
64-Inch Pipe (2,475 LF)	Heavy Cleaning	\$500/ton	1,800	\$900,000
75-Inch Pipe (1,534 LF)	Heavy Cleaning	\$500/ton	1,600	\$800,000
1.25 MG Storage Tank Near WR	New	\$6/gallon	1.25 MG	\$7,500,000
3.75 MG Storage Tank Near JFPS	New	\$6/gallon	3.75 MG	\$22,500,000
Subtotal				\$107,236,357
Eng. Design, Const Mgt/Insp, Admin, Post Eng. Svcs & Cont. (42%)				\$45,039,270
2008 Total Estimated Cost				\$152,280,000
2009 Total Estimated Cost				\$162,940,000
2010 Total Estimated Cost				\$174,350,000
2011 Total Estimated Cost				\$186,550,000



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TABLE 4.10				
10-Year Jones Falls Improvements				
Diameter	Rehab Method	Unit Cost	Quantity (LF)	Cost
2012 Total Estimated Cost				\$199,610,000
2013 Total Estimated Cost				\$213,580,000
2014 Total Estimated Cost				\$228,530,000
2015 Total Estimated Cost				\$244,530,000
2016 Total Estimated Cost				\$261,650,000
2017 Total Estimated Cost				\$279,970,000

5.0 15-YEAR IMPROVEMENTS

See Map 5.0 for a detailed map showing the locations of the following projects described on a sub-sewershed basis. The work described below is additive to the work required for a 2, 5, and 10-year event.

5.1 Barclay Street

No required improvements.

5.2 Bolton Hill

No required improvements.

5.3 Greenmount Avenue

For the 15-year, 24 hour storm event, overflows occurred in flow meter basin JF04 and JF06. Therefore, it is recommended to complete the I&I removal project for these two basins. The work required for the JF04 flow meter basin is discussed in Section 3.3. However, if the I&I abatement option for the 5 and 10-year storms was completed, no additional work is required in JF04 flow meter basin. It is recommended to CIPP line all the pipes and rehabilitate all manholes beginning at MH S43SS_007MH, located in Aisquith Street, near Montpelier Street, and include all the pipes and manhole upstream that were not rehabilitated as part of the Paragraph 8 project, SC 820. For the JF06 basin, it is recommended to start the rehabilitation project at MH S39YY_002MH, located in Avon Avenue, and proceed upstream.

By completing this I&I reduction project, the estimated dry weather infiltration reduces from 295,000 gpd to 176,000 gpd, for an annual convey and treat savings of \$65,000 and the 15-year storm RDII volume reduces from 4.2 MG to 2.7 MG for a 15-year storm convey and treat savings of \$2,200. The costs to complete this proposed work is presented in Table 5.3.



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TABLE 5.3				
15-Year Greenmount Avenue Improvements				
Diameter	Rehab Method	Unit Cost	Quantity (LF)	Cost
8-Inch Pipe	CIPP	\$45	44,521	\$2,003,445
10-Inch Pipe	CIPP	\$64	2,889	\$184,896
Manholes(each)	Rehab	\$3,719	277	\$1,030,163
Subtotal				\$3,218,504
Eng. Design, Const Mgt/Insp, Admin, Post Eng. Svcs & Cont. (42%)				\$1,351,772
2008 Total Estimated Cost				\$4,570,000
2009 Total Estimated Cost				\$4,890,000
2010 Total Estimated Cost				\$5,230,000
2011 Total Estimated Cost				\$5,600,000
2012 Total Estimated Cost				\$5,990,000
2013 Total Estimated Cost				\$6,410,000
2014 Total Estimated Cost				\$6,860,000
2015 Total Estimated Cost				\$7,340,000
2016 Total Estimated Cost				\$7,850,000
2017 Total Estimated Cost				\$8,400,000

5.4 Hampden Avenue

No required improvements.

5.5 Lower Jones Falls

To convey the flow in the Lower Jones Falls without an overflow for the 15-year storm event, two alternatives were developed. The first alternative is to install a 3,140 foot long, 60-inch diameter relief sewer from MH S33KK_051MH located in Falls Road to MH S37GG_007MH located just north of Preston Street. The majority of the proposed sewer is located within the railroad right of way; therefore the sewer most likely will have to be tunneled, significantly increasing the cost of installation. Utilizing or obtaining right of ways in the CSX railroad will be a major task. This could possibly lead to longer design and permitting times, thus increasing administrative costs with a longer project. The estimated unit cost per foot includes these additional costs. A possible advantage to this alternative is that the Jones Falls Pumping Station will not require any modifications or storage tanks as described for the 10-year storm. However, it is recommended to keep the storage tank to help reduce peak flows overwhelming other downstream sewersheds and the Back River Wastewater Treatment Plan.

An alternative to installing the 60-inch relief sewer as described above is to pressurize the Lower Jones Fall Interceptor. This involves sealing all of the manholes along the Lower Jones Fall interceptor from 800 feet north of the Jones Falls siphon to MH



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S37GG_007MH along with the first manhole on all side branches. Pressurizing the system means that air release valves will have to be installed along with engineered sealed portals to access the sewer during low flows for maintenance. Sealing the sewer will make maintenance more difficult, may cause an increase in corrosion, generate odors, and increases the peak flow rate downstream. A 60-inch relief sewer provides about 0.5 MG of storage and decreases the velocity of the wastewater compared to a pressurized system. Therefore, it is recommended to install the 60-inch relief sewer versus pressurizing the Lower Jones Falls.

TABLE 5.5				
15-Year Lower Jones Falls Improvements				
Diameter	Rehab Method	Unit Cost	Quantity (LF)	Cost
60-Inch Pipe	Tunnel	\$8,000	3,140	\$25,120,000
Manholes(each)	New	\$3,719	9	\$33,471
Subtotal				\$25,153,471
Eng. Design, Const Mgt/Insp, Admin, Post Eng. Svcs & Cont. (42%)				\$10,564,458
2008 Total Estimated Cost				\$35,720,000
2009 Total Estimated Cost				\$38,220,000
2010 Total Estimated Cost				\$40,900,000
2011 Total Estimated Cost				\$43,760,000
2012 Total Estimated Cost				\$46,820,000
2013 Total Estimated Cost				\$50,100,000
2014 Total Estimated Cost				\$53,610,000
2015 Total Estimated Cost				\$57,360,000
2016 Total Estimated Cost				\$61,380,000
2017 Total Estimated Cost				\$65,680,000

5.6 Maryland Avenue

No required improvements.

5.7 Stony Run

For the 15-year storm event, it is recommended to rehabilitate flow meter basins JF24 and JF25. These two basins have elevated RDII rates along with deteriorated pipe based on internal CCTV inspections. It is recommended to CIPP line all the sewers and rehabilitated all the manholes between MH S31GG1094MH located south of University Parkway to MH S29OO1019MH located north of Cold Spring Lane, including all of the branch lines between these two manholes. Following completion of this I&I removal project, the average daily dry weather convey and treat volume will reduce from 214,000 gpd to 129,000 gpd for a yearly savings of \$46,000. The 15-year RDII volume will reduce from 2.0 MG to 1.0 MG for a per storm savings of \$1,500. The costs



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associated with all the improvements to convey the 15-year, 24 hour storm event are presented in Table 5.7.

TABLE 5.7				
15-Year Stony Run Improvements				
Item	Rehab Method	Unit Cost	Quantity (LF)	Cost
8-Inch Pipe	CIPP	\$45	63,459	\$2,855,655
10-Inch Pipe	CIPP	\$64	816	\$52,224
Subtotal				\$2,907,879
Eng. Design, Const Mgt/Insp, Admin, Post Eng. Svcs & Cont. (42%)				\$1,221,309
2008 Total Estimated Cost				\$4,130,000
2009 Total Estimated Cost				\$4,420,000
2010 Total Estimated Cost				\$4,730,000
2011 Total Estimated Cost				\$5,060,000
2012 Total Estimated Cost				\$5,410,000
2013 Total Estimated Cost				\$5,790,000
2014 Total Estimated Cost				\$6,200,000
2015 Total Estimated Cost				\$6,630,000
2016 Total Estimated Cost				\$7,090,000
2017 Total Estimated Cost				\$7,590,000

5.8 Upper Jones Falls

In the JF38 flow meter basin, it is recommended to upsize the 2,332 foot long reach of sewer between MHs S17KK1001MH to S15MM1012MH, along Greenspring Avenue, from 15-inches to 18-inches in diameter.

To convey the flows in the JF43 flow meter basin without an overflow, it is recommended to increase the 1,262 foot long reach of 10-inch sewer between MH S17WW1006MH to MH S17UU1008MH, both located in Clyburn Avenue to 12-inches in diameter.

In the vicinity just south of the JF45 flow meter basin, the 350 foot reach between MH S19AA2060MH and S19AA2052MH needs to be upsized from 8-inches to 15-inches, located underneath the Jones Falls Expressway, north of Northern Parkway

In the JF46 flow meter basin, an 880 foot reach of 12-inch pipe needs to be upsized to a 15-inch diameter pipe to prevent SSOs from occurring for the 15-year storm. The project begins at MH S21AA2011MH located in Sabina Avenue and goes west to MH S19CC2034MH.



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In the JF47 flow meter basin, the 603 foot reach of 8-inch pipe between MHs S21II2010MH and S21II2014MH located adjacent to Bryn Mawr Road needs to be upsized to 10-inches in diameter.

The proposed storage facility located near Western Run for the 15-year storm must be able to hold 3.0 MG of wastewater to prevent SSOs from occurring. This is an additional 1.75 MG required over the 10-year storm. The costs associated with all these projects are presented in Table 5.8.

TABLE 5.8				
15-Year Upper Jones Falls Improvements				
Diameter	Rehab Method	Unit Cost	Quantity (LF)	Cost
10-Inch Pipe	Replace	\$495	1865	\$923,175
15-Inch Pipe	Replace	\$585	1230	\$719,550
18-Inch Pipe	Replace	\$1,080	2332	\$2,518,560
Manholes(each)	Replace	\$3,719	38	\$141,322
3 MG Storage Tank Near WR	New	\$6/gallon	3 MG	\$18,000,000
Subtotal				\$22,302,607
Eng. Design, Const Mgt/Insp, Admin, Post Eng. Svcs & Cont. (42%)				\$9,367,095
2008 Total Estimated Cost				\$31,670,000
2009 Total Estimated Cost				\$33,890,000
2010 Total Estimated Cost				\$36,260,000
2011 Total Estimated Cost				\$38,800,000
2012 Total Estimated Cost				\$41,520,000
2013 Total Estimated Cost				\$44,430,000
2014 Total Estimated Cost				\$47,540,000
2015 Total Estimated Cost				\$50,870,000
2016 Total Estimated Cost				\$54,430,000
2017 Total Estimated Cost				\$58,240,000

5.9 Western Run

For the 15-year, 24 hour storm event, overflows occur throughout the Western Run basin, in addition to the improvements for the 10-year, 24 hour storm event, the following upgrades are recommended to prevent overflows for the 15-year, 24 hour storm event:

In the JFWR29 flow meter basin, it is recommend to rehabilitate the entire public sewer infrastructure upstream of MH S06EE2006MH, located in Glengyle Avenue.

For the overflows upstream of flow meter JF03_20S, located in Baltimore County, it is recommended to upsize 2,908 feet of existing 8-inch pipe to 15-inch pipe, upstream of MH S06GG2006MH from Wallis Road north east to the City/County boundary. An



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alternative would be to mandate RDII reductions in Baltimore County of a least 40 percent.

In JFWR07, it is recommended to upsize the 891 feet of 10 inch pipe to 12-inch pipe between MHs S04CC2003MH and S04AA2016MH located in Labyrinth Road.

In JFWR19, two projects are required to eliminate overflows for the 15-year event. The first project is to increase the 407 foot long reach of 12-inch sewer between MHs S07YY1016MH and S07YY1006MH, located on Glen Avenue to 15-inches. The second project is to increase/replace to 10-inches the 869 foot long reach of 8-inch and 10-inch pipe between MHs S05WW1016MH and S05UU1012MH, located between Sulgrave Avenue and Northern Parkway.

It is recommended to rehabilitate all the sewers and manholes in the JFWR17 flow meter basin that were not previously recommended for rehabilitation. The project should begin at MH S09CC2014MH (adjacent to Pimlico Road) and proceed upstream.

In JFWR14, it is recommended to upsize approximately 2,484 feet of 15-inch pipe from MH S09II2010MH to S05II2009MH, located in Green Meadow Parkway to 18-inches.

In JFWR12, it is recommended to reduce I&I through an extensive rehabilitation program through out the basin, beginning at MH S11EE2032MH and proceeding upstream.

In JFWR11, it is proposed to upsize approximately 790 feet of existing 10-inch pipe to 12-inch pipe from MH S13CC2021MH to MH S13AA2012MH along Cross Country Boulevard.

Following completion of all the recommended I&I removal projects, the average daily dry weather convey and treat volume will reduce from 220,000 gpd to 132,000 gpd for a yearly savings of \$51,000. The 15-year RDII volume will reduce from 2.2 MG to 1.0 MG for a per storm savings of \$1,850. The costs associated with all the improvements to convey the 15-year, 24 hour storm event are presented in Table 5.9.



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TABLE 5.9				
15-Year Western Run Improvements				
Diameter	Rehab Method	Unit Cost	Quantity (LF)	Cost
8-Inch Pipe	CIPP	\$45	26,996	\$1,214,820
10-Inch Pipe	CIPP	\$64	6,872	\$439,808
12-Inch Pipe	CIPP	\$87	79	\$6,873
15-Inch Pipe	CIPP	\$87	209	\$18,183
10-Inch Pipe	Replace	\$495	869	\$430,155
12-Inch Pipe	Replace	\$585	1681	\$983,385
15-Inch Pipe	Replace	\$585	233	\$136,305
18-Inch Pipe	Replace	\$1,080	2484	\$2,682,720
Manholes(each)	Rehab	\$3,719	190	\$706,610
Manholes(each)	Replace	\$3,719	35	\$130,165
Subtotal				\$6,749,024
Eng. Design, Const Mgt/Insp, Admin, Post Eng. Svcs & Cont. (42%)				\$2,834,590
2008 Total Estimated Cost				\$9,580,000
2009 Total Estimated Cost				\$10,250,000
2010 Total Estimated Cost				\$10,970,000
2011 Total Estimated Cost				\$11,740,000
2012 Total Estimated Cost				\$12,560,000
2013 Total Estimated Cost				\$13,440,000
2014 Total Estimated Cost				\$14,380,000
2015 Total Estimated Cost				\$15,390,000
2016 Total Estimated Cost				\$16,470,000
2017 Total Estimated Cost				\$17,620,000

5.10 15-Year Summary

The combined cost estimate for all improvements recommended to convey the 15-year, 24 hour storm event in the Jones Falls Sewershed is presented in Table 5.10. The quantities and costs include the recommendations to convey the 2-year, 5-year, and 10-year event, since those improvements are required to convey the 15-year event as well. The 20 (2, 5, 10, and 15-year improvements) recommended I&I reduction projects are estimated to save the City approximately \$1,292,000 (2008 dollars) per year in treatment costs. The average cost to eliminate each gallon of estimated overflow is estimated to be \$6.06 in 2008 dollars; however, the cost to eliminate the overflows moving from the 10-year improvements to the 15-year improvements is estimated to be \$147.91 per gallon in 2008 dollars.



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TABLE 5.10 15-Year Jones Falls Improvements				
Diameter	Rehab Method	Unit Cost	Quantity (LF)	Cost
8-Inch Pipe	CIPP	\$45	644,402	\$28,998,090
10-Inch Pipe	CIPP	\$64	53,811	\$3,443,904
12-Inch Pipe	CIPP	\$87	17,474	\$1,520,238
15-Inch Pipe	CIPP	\$87	8,291	\$721,317
18-Inch Pipe	CIPP	\$124	1,875	\$232,500
20-Inch Pipe	CIPP	\$124	755	\$93,620
21-Inch Pipe	CIPP	\$124	1,033	\$128,092
24-Inch Pipe	CIPP	\$169	2,107	\$356,083
42-Inch Pipe	CIPP	\$385	7,488	\$2,882,880
10-Inch Pipe	Replacement	\$495	3,071	\$1,520,145
12-Inch Pipe	Replacement	\$585	10,560	\$6,177,600
15-Inch Pipe	Replacement	\$585	12,477	\$7,299,045
18-Inch Pipe	Replacement	\$1,080	5,926	\$6,400,080
21-Inch Pipe	Replacement	\$1,080	3,303	\$3,567,240
24-Inch Pipe	Replacement	\$1,440	1,234	\$1,776,960
30-Inch Pipe	Replacement	\$1,530	6,630	\$10,143,900
36-Inch Pipe	Replacement	\$1,620	275	\$445,500
60-Inch Pipe	Tunnel	\$8,000	3,140	\$25,120,000
Manholes(each)	Rehab	\$3,719	3,843	\$14,292,117
Manholes(each)	Replacement	\$3,719	269	\$1,000,411
Stony Run PS Modifications	Reprogram	\$25,000	1	\$25,000
42-Inch Pipe	CCTV	\$5	7,488	\$37,440
Open Sluice Gates (each)		\$1,000	4	\$4,000
24" Siphon	Replacement	\$1,440	522	\$751,680
36" Siphon	Replacement	\$1,620	250	\$405,000
50-Inch Pipe (1,924 LF)	Heavy Cleaning	\$500/ton	850	\$425,000
56-Inch Pipe (370 LF)	Heavy Cleaning	\$500/ton	200	\$100,000
64-Inch Pipe (2,475 LF)	Heavy Cleaning	\$500/ton	1,800	\$900,000
75-Inch Pipe (1,534 LF)	Heavy Cleaning	\$500/ton	1,600	\$800,000
3 MG Storage Tank Near WR	New	\$6/gallon	3 MG	\$18,000,000
3.75 MG Storage Tank Near JFPS	New	\$6/gallon	3.75 MG	\$22,500,000
Subtotal				\$160,067,842
Eng. Design, Const Mgt/Insp, Admin, Post Eng. Svcs & Cont. (42%)				\$67,228,494
2008 Total Estimated Cost				\$227,300,000
2009 Total Estimated Cost				\$243,210,000



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TABLE 5.10				
15-Year Jones Falls Improvements				
Diameter	Rehab Method	Unit Cost	Quantity (LF)	Cost
2010 Total Estimated Cost				\$260,230,000
2011 Total Estimated Cost				\$278,450,000
2012 Total Estimated Cost				\$297,940,000
2013 Total Estimated Cost				\$318,800,000
2014 Total Estimated Cost				\$341,120,000
2015 Total Estimated Cost				\$365,000,000
2016 Total Estimated Cost				\$390,550,000
2017 Total Estimated Cost				\$417,890,000

6.0 20-YEAR IMPROVEMENTS

See Map 6.0 for a detailed map showing the locations of the following projects described on a sub-sewershed basis. The work described below is additive to the work required for a 2, 5, 10, and 15-year storm events.

6.1 Barclay Street

No required improvements.

6.2 Bolton Hill

No required improvements.

6.3 Greenmount Avenue

No required improvements.

6.4 Hampden Avenue

For the 20-year storm event, there is only one manhole that overflows. MH S33WW_041MH, located adjacent to 31 Street, is located at the bottom of a little ravine and is the low point of the system. Simply by elevating the manhole rim elevation 2 feet eliminates SSO activity for the 20-year event. The cost associated with elevating this manhole is in Table 5.4



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TABLE 6.4				
15-Year Hampden Avenue Improvements				
Diameter	Rehab Method	Unit Cost	Quantity (LF)	Cost
Manholes(each)	Rehab	\$3,719	1	\$3,719
Subtotal				\$3,719
Eng. Design, Const Mgt/Insp, Admin, Post Eng. Svcs & Cont. (42%)				\$1,562
2008 Total Estimated Cost				\$5,300
2009 Total Estimated Cost				\$5,700
2010 Total Estimated Cost				\$6,100
2011 Total Estimated Cost				\$6,500
2012 Total Estimated Cost				\$7,000
2013 Total Estimated Cost				\$7,500
2014 Total Estimated Cost				\$8,000
2015 Total Estimated Cost				\$8,600
2016 Total Estimated Cost				\$9,200
2017 Total Estimated Cost				\$9,800

6.5 Lower Jones Falls

As with the 15-year storm event, sealing and pressurizing the Lower Jones Falls Interceptor provides protection for the 20-year event. However, as previously mentioned, this could make maintenance operations more difficult versus an unsealed system. An alternative to this is to extend the proposed 60-inch relief sewer discussed in Section 5.5 to the High Level Interceptor. The costs associated with the additional length of 60-inch pipe required are presented in Table 6.5.



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TABLE 6. 5				
20-Year Lower Jones Falls Improvements				
Diameter	Rehab Method	Unit Cost	Quantity (LF)	Cost
60-Inch Pipe	New	\$8,000	1,570	\$12,560,000
Manholes(Each)	New	\$3,719	7	\$26,033
Subtotal				\$12,586,033
Eng. Design, Const Mgt/Insp, Admin, Post Eng. Svcs & Cont. (42%)				\$5,286,134
2008 Total Estimated Cost				\$17,872,200
2009 Total Estimated Cost				\$19,123,300
2010 Total Estimated Cost				\$20,461,900
2011 Total Estimated Cost				\$21,894,200
2012 Total Estimated Cost				\$23,426,800
2013 Total Estimated Cost				\$25,066,700
2014 Total Estimated Cost				\$26,821,400
2015 Total Estimated Cost				\$28,698,900
2016 Total Estimated Cost				\$30,707,800
2017 Total Estimated Cost				\$32,857,300

6.6 Maryland Avenue

No required improvements.

6.7 Stony Run

To convey the flow for the 20-year storm event, it is required to upsize 2,357 feet of 24-inch sewer between MHs S29MM1002MH and S29GG1006MH located adjacent to Linkwood Road to a 30-inch diameter pipe. The costs associated with this upgrade are presented in Table 6.7.



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TABLE 6.7				
20-Year Stony Run Improvements				
Item	Rehab Method	Unit Cost	Quantity (LF)	Cost
30-Inch Pipe	Replacement	\$1,530	2,357	\$3,606,210
Manholes(each)	Replacement	\$3,719	11	\$40,909
Subtotal				\$3,647,119
Eng. Design, Const Mgt/Insp, Admin, Post Eng. Svcs & Cont. (42%)				\$1,531,790
2008 Total Estimated Cost				\$5,180,000
2009 Total Estimated Cost				\$5,540,000
2010 Total Estimated Cost				\$5,930,000
2011 Total Estimated Cost				\$6,350,000
2012 Total Estimated Cost				\$6,790,000
2013 Total Estimated Cost				\$7,270,000
2014 Total Estimated Cost				\$7,780,000
2015 Total Estimated Cost				\$8,320,000
2016 Total Estimated Cost				\$8,900,000
2017 Total Estimated Cost				\$9,520,000

6.8 Upper Jones Falls

To prevent SSOs for the 20-year storm in the JF42 flow meter basin in the Upper Jones Falls sub-sewershed, the 792 foot reach of 10-inch and 12-inch pipe must be upsized to 15-inch pipe from MH S23WW1048MH, located in Springhouse Path to MH S21WW1008MH, located in Cross Keys Road.

To prevent SSOs for the 20-year storm in the JF47 flow meter basin in the Upper Jones Falls sub-sewershed, the 1,245 foot reach of 10-inch and 12-inch pipe must be upsized to 15-inch pipe from MH S21II2014MH, located adjacent to Bryn Mawr Road to MH S19GG2016MH, located in Falls Road.

To convey the flows in the Upper Jones Falls Interceptor, the 770 feet of 42 inch pipe between MH S19GG2004MH located at the eastern terminus of Bulgrave Avenue and MH S19EE2015MH located Cottonworth Avenue, must be upsized to a 48-inch diameter pipe. This extends the 48-inch pipe installed under SC 772 to the entrance of the Western Run interceptors. In the southern section of the Upper Jones Falls basin, it is recommended to construct a 3,600 foot long, 42-inch parallel interceptor to the existing 48-inch Upper Jones Falls interceptor from just north of Cold Spring Lane at MH S19OO1042MH to MH S21GG1013MH adjacent to the Jones Falls Expressway, north of West 41 Street. This would extend the 42 and 48-inch parallel interceptors to the existing 60-inch diameter interceptor.

As beginning with the 10-year event, no flow can be allowed to by-pass the Jones Falls Pumping Station to the Lower Jones Falls. Either the Jones Falls Pumping Station must



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be increased to 85 MGD (or 30 MGD wet weather pumping station) or a 6.75 MG storage facility must be constructed. The storage facility is the recommended option to minimize downstream improvements. The volume of the Western Run area storage facility actually decreases, due to the additional 42-inch relief sewer, by 0.75 MG to 2.25 MG from the 15-year event. The costs associated with these upgrades are presented in Table 6.8.

TABLE 6.8				
20-Year Upper Jones Falls Improvements				
Diameter	Rehab Method	Unit Cost	Quantity (LF)	Cost
15-Inch Pipe	Replacement	\$585	2,037	\$1,191,645
42-Inch Pipe	New	\$1,710	3,600	\$6,156,000
48-Inch Pipe	New	\$1,800	770	\$1,386,000
Manholes(each)	Replacement	\$3,719	42	\$156,198
2.25 MG Storage Tank near WR	New	\$6/gallon	2.25 MG	\$13,500,000
6.75 MG Storage Tank near JFPS	New	\$6/gallon	6.75 MG	\$40,500,000
Subtotal				\$62,889,843
Eng. Design, Const Mgt/Insp, Admin, Post Eng. Svcs & Cont. (42%)				\$26,413,734
2008 Total Estimated Cost				\$89,303,600
2009 Total Estimated Cost				\$95,554,900
2010 Total Estimated Cost				\$102,243,700
2011 Total Estimated Cost				\$109,400,800
2012 Total Estimated Cost				\$117,058,900
2013 Total Estimated Cost				\$125,253,000
2014 Total Estimated Cost				\$134,020,700
2015 Total Estimated Cost				\$143,402,100
2016 Total Estimated Cost				\$153,440,200
2017 Total Estimated Cost				\$164,181,000

6.9 Western Run

For the 20-year, 24 hour storm event, overflows occur throughout the basin. In addition to the improvements for the 15-year, 24 hour storm event, the following upgrades are recommended to prevent overflows for the 20-year, 24 hour storm event:

In the JFWR29 flow meter basin, it is proposed to increase 1,200 feet of existing 18-inch pipe to 24-inches in diameter between MHs S04EE2026MH and S06GG2011MH, located on Wallis Avenue. Also, the 44 feet of 10-inch pipe between MHs S04CC2018MH and S04CC2008MH, located on Labyrinth Avenue, needs to be increased to 12-inches in diameter.



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In the JFWR07 flow meter basin, it is recommended to construct a 100 foot long, 15-inch, overflow cross connection between MH S02CC2013MH and the new 24-inch line constructed under SC 789 between Cross Country Boulevard and Western Run Drive. The cross connection should exit MH S02CC2013MH at elevation 402' and enter the existing 24-inch line at elevation 400'.

In the western portion of the Western Run Interceptors, the 4,538 foot reach of existing 21-inch pipe between MHs S01CC2004MH and S07AA2017MH, in Cross Country Boulevard, needs to be replaced with 24-inch diameter pipe. Then, the 2,158 foot reach of 24-inch pipe between MHs S07AA2017MH to S09CC2029MH, in Cross Country Boulevard, needs to be increased to 30-inches in diameter.

In JFWR19, 871 feet of existing 8-inch pipe needs to be upsized to 10-inches between MHs S07YY1007MH and S09WW1002MH, in Woodcrest Avenue.

In JFWR11, the 1,079 of existing 10-inch pipe needs to be increased to 15-inches in diameter, between MHs S13CC2006MH and S13EE2034MH, east of Cross Country Boulevard.

Lastly, in the eastern section of Western Run, the northern parallel interceptor needs to be upsized from 15, 16, 18, 21, and 24-inches to 30-inch pipe. This 5,919 foot long project is sited between MHS S17EE2003MH and S09CC2131MH, located north of Cross Country Drive and Kelly Avenue. The existing 16-inch sluice gate at MH S09CC2131MH will need to be replaced with a 30-inch gate. Another 24-inch (44 foot long), overflow cross connection between the southern and northern lines is proposed between MHs S13EE2025MH and S13EE2031MH.

The costs associated with all the improvements to convey the 20-year, 24 hour storm event are presented in Table 6.9.



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TABLE 6.9				
20-Year Western Run Improvements				
Diameter	Rehab Method	Unit Cost	Quantity (LF)	Cost
10-Inch Pipe	Replacement	\$495	871	\$431,145
12-Inch Pipe	Replacement	\$585	44	\$25,740
15-Inch Pipe	Replacement	\$585	1174	\$686,790
24-Inch Pipe	Replacement	\$1,440	5,799	\$8,350,560
30-Inch Pipe	Replacement	\$1,530	8062	\$12,334,860
Manholes(each)	Replacement	\$3,719	100	\$371,900
Subtotal				\$22,200,995
Eng. Design, Const Mgt/Insp, Admin, Post Eng. Svcs & Cont. (42%)				\$9,324,418
2008 Total Estimated Cost				\$31,525,400
2009 Total Estimated Cost				\$33,732,200
2010 Total Estimated Cost				\$36,093,500
2011 Total Estimated Cost				\$38,620,000
2012 Total Estimated Cost				\$41,323,400
2013 Total Estimated Cost				\$44,216,000
2014 Total Estimated Cost				\$47,311,100
2015 Total Estimated Cost				\$50,622,900
2016 Total Estimated Cost				\$54,166,500
2017 Total Estimated Cost				\$57,958,200

6.10 20-Year Summary

The combined cost estimate for all improvements recommended to convey the 20-year, 24 hour storm event in the Jones Falls Sewershed is presented in Table 6.10. The quantities and costs include the recommendations to convey the 2-year, 5-year, 10-year, and 15-year event, since those improvements are required to convey the 20-year event as well. The average cost to eliminate each gallon of estimated overflow is estimated to be \$7.45 in 2008 dollars; however, the cost to eliminate the overflows moving from the 15-year improvements to the 20-year improvements is estimated to be \$332.38 per gallon in 2008 dollars.



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TABLE 6.10 20-Year Jones Falls Improvements				
Diameter	Rehab Method	Unit Cost	Quantity (LF)	Cost
8-Inch Pipe	CIPP	\$45	644,402	\$28,998,090
10-Inch Pipe	CIPP	\$64	53,811	\$3,443,904
12-Inch Pipe	CIPP	\$87	17,474	\$1,520,238
15-Inch Pipe	CIPP	\$87	8,291	\$721,317
18-Inch Pipe	CIPP	\$124	1,875	\$232,500
20-Inch Pipe	CIPP	\$124	755	\$93,620
21-Inch Pipe	CIPP	\$124	1,033	\$128,092
24-Inch Pipe	CIPP	\$169	2,107	\$356,083
42-Inch Pipe	CIPP	\$385	7,488	\$2,882,880
10-Inch Pipe	Replacement	\$495	3,942	\$1,951,290
12-Inch Pipe	Replacement	\$585	10,604	\$6,203,340
15-Inch Pipe	Replacement	\$585	15,688	\$9,177,480
18-Inch Pipe	Replacement	\$1,080	5,926	\$6,400,080
21-Inch Pipe	Replacement	\$1,080	3,303	\$3,567,240
24-Inch Pipe	Replacement	\$1,440	7,033	\$10,127,520
30-Inch Pipe	Replacement	\$1,530	17,409	\$26,635,770
36-Inch Pipe	Replacement	\$1,620	275	\$445,500
42-Inch Pipe	New	\$1,710	3,600	\$6,156,000
48-Inch Pipe	Replacement	\$1,800	770	\$1,386,000
60-Inch Pipe	Tunnel	\$8,000	4,710	\$37,680,000
Manholes(each)	Rehab	\$3,719	3,843	\$14,292,117
Manholes(each)	Replacement	\$3,719	430	\$1,599,170
Stony Run PS Modifications	Reprogram	\$25,000	1	\$25,000
42-Inch Pipe	CCTV	\$5	7,488	\$37,440
Open Sluice Gates (each)		\$1,000	4	\$4,000
24" Siphon	Replacement	\$1,440	522	\$751,680
36" Siphon	Replacement	\$1,620	250	\$405,000
50-Inch Pipe (1,924 LF)	Heavy Cleaning	\$500/ton	850	\$425,000
56-Inch Pipe (370 LF)	Heavy Cleaning	\$500/ton	200	\$100,000
64-Inch Pipe (2,475 LF)	Heavy Cleaning	\$500/ton	1,800	\$900,000
75-Inch Pipe (1,534 LF)	Heavy Cleaning	\$500/ton	1,600	\$800,000
2.25 MG Storage Tank Near WR	New	\$6/gallon	2.25 MG	\$13,500,000
6.75 MG Storage Tank Near JFPS	New	\$6/gallon	6.75 MG	\$40,500,000
Subtotal				\$221,446,351
Eng. Design, Const Mgt/Insp, Admin, Post Eng. Svcs & Cont. (42%)				\$93,007,467



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TABLE 6.10				
20-Year Jones Falls Improvements				
Diameter	Rehab Method	Unit Cost	Quantity (LF)	Cost
2008 Total Estimated Cost				\$314,450,000
2009 Total Estimated Cost				\$336,460,000
2010 Total Estimated Cost				\$360,010,000
2011 Total Estimated Cost				\$385,210,000
2012 Total Estimated Cost				\$412,170,000
2013 Total Estimated Cost				\$441,020,000
2014 Total Estimated Cost				\$471,890,000
2015 Total Estimated Cost				\$504,920,000
2016 Total Estimated Cost				\$540,260,000
2017 Total Estimated Cost				\$578,080,000

7.0 SUMMARY

The total improvement costs per sub-sewershed based per design storm return period are presented in Table 7.1 on the following page. The costs for each storm event include the previous design storm's improvement costs plus the costs required for that year's event. Table 7.2 shows the cost per gallon of SSO removed for both complete storm improvements and incremental costs for moving from one storm to the next.



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TABLE 7.1

Total Estimated Improvement Costs for Jones Falls

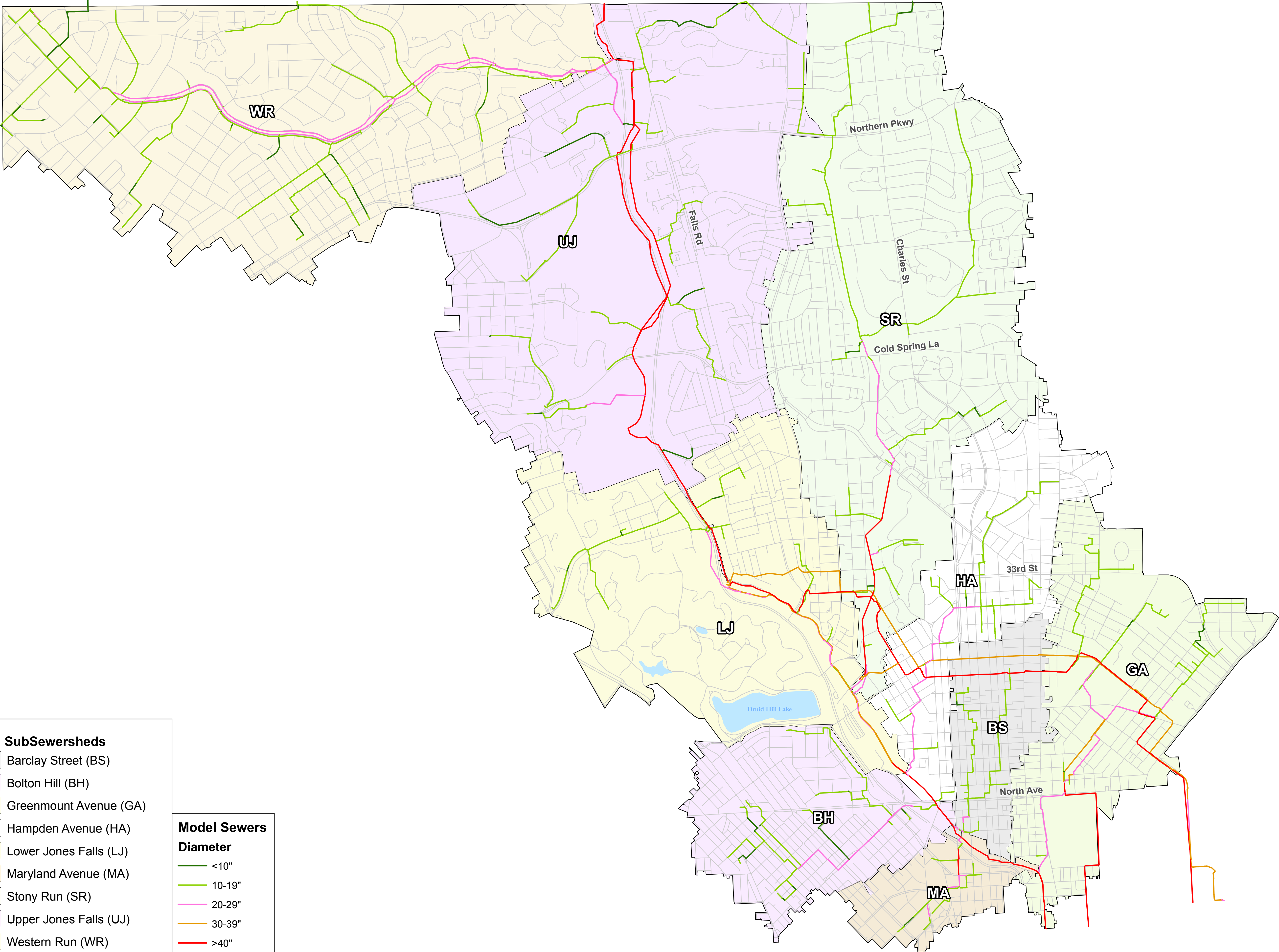
Projected Year	2 Year	5 Year		10 Year		15 Year		20 Year	
		Additional	Cumulative	Additional	Cumulative	Additional	Cumulative	Additional	Cumulative
2008	\$21,680,000	\$46,070,000	\$67,750,000	\$84,530,000	\$152,280,000	\$75,020,000	\$227,300,000	\$87,150,000	\$314,450,000
2009	\$23,200,000	\$49,290,000	\$72,490,000	\$90,450,000	\$162,940,000	\$80,270,000	\$243,210,000	\$93,250,000	\$336,460,000
2010	\$24,820,000	\$52,740,000	\$77,560,000	\$96,790,000	\$174,350,000	\$85,880,000	\$260,230,000	\$99,780,000	\$360,010,000
2011	\$26,560,000	\$56,430,000	\$82,990,000	\$103,560,000	\$186,550,000	\$91,900,000	\$278,450,000	\$106,760,000	\$385,210,000
2012	\$28,420,000	\$60,380,000	\$88,800,000	\$110,810,000	\$199,610,000	\$98,330,000	\$297,940,000	\$114,230,000	\$412,170,000
2013	\$30,410,000	\$64,610,000	\$95,020,000	\$118,560,000	\$213,580,000	\$105,220,000	\$318,800,000	\$122,220,000	\$441,020,000
2014	\$32,540,000	\$69,130,000	\$101,670,000	\$126,860,000	\$228,530,000	\$112,590,000	\$341,120,000	\$130,770,000	\$471,890,000
2015	\$34,820,000	\$73,970,000	\$108,790,000	\$135,740,000	\$244,530,000	\$120,470,000	\$365,000,000	\$139,920,000	\$504,920,000
2016	\$37,260,000	\$79,150,000	\$116,410,000	\$145,240,000	\$261,650,000	\$128,900,000	\$390,550,000	\$149,710,000	\$540,260,000
2017	\$39,870,000	\$84,690,000	\$124,560,000	\$155,410,000	\$279,970,000	\$137,920,000	\$417,890,000	\$160,190,000	\$578,080,000

TABLE 7.2

Estimated Improvement Costs Per Gallon SSO Removed

	2 Year	5 Year		10 Year		15 Year		20 Year	
		Additional	Cumulative	Additional	Cumulative	Additional	Cumulative	Additional	Cumulative
Gallons	9,584,000	4,298,300	23,490,000	2,853,700	32,344,000	507,200	37,497,000	262,200	42,220,000
2008	\$2.26	\$10.72	\$2.88	\$29.62	\$4.71	\$147.91	\$6.06	\$332.38	\$7.45
2009	\$2.42	\$11.47	\$3.09	\$31.70	\$5.04	\$158.26	\$6.49	\$355.64	\$7.97
2010	\$2.59	\$12.27	\$3.30	\$33.92	\$5.39	\$169.32	\$6.94	\$380.55	\$8.53
2011	\$2.77	\$13.13	\$3.53	\$36.29	\$5.77	\$181.19	\$7.43	\$407.17	\$9.12
2012	\$2.97	\$14.05	\$3.78	\$38.83	\$6.17	\$193.87	\$7.95	\$435.66	\$9.76
2013	\$3.17	\$15.03	\$4.05	\$41.55	\$6.60	\$207.45	\$8.50	\$466.13	\$10.45
2014	\$3.40	\$16.08	\$4.33	\$44.45	\$7.07	\$221.98	\$9.10	\$498.74	\$11.18
2015	\$3.63	\$17.21	\$4.63	\$47.57	\$7.56	\$237.52	\$9.73	\$533.64	\$11.96
2016	\$3.89	\$18.41	\$4.96	\$50.90	\$8.09	\$254.14	\$10.42	\$570.98	\$12.80
2017	\$4.16	\$19.70	\$5.30	\$54.46	\$8.66	\$271.92	\$11.14	\$610.95	\$13.69





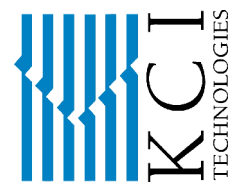

SubSewersheds

- Barclay Street (BS)
- Bolton Hill (BH)
- Greenmount Avenue (GA)
- Hampden Avenue (HA)
- Lower Jones Falls (LJ)
- Maryland Avenue (MA)
- Stony Run (SR)
- Upper Jones Falls (UJ)
- Western Run (WR)


Model Sewers

Diameter

- <10"
- 10-19"
- 20-29"
- 30-39"
- >40"




In association with



November 17, 2008

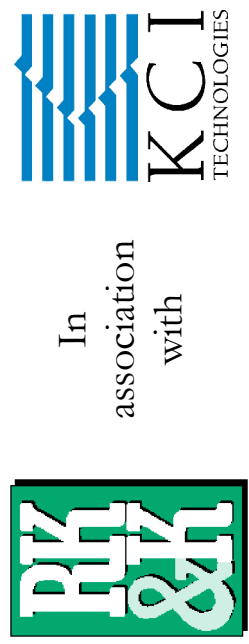
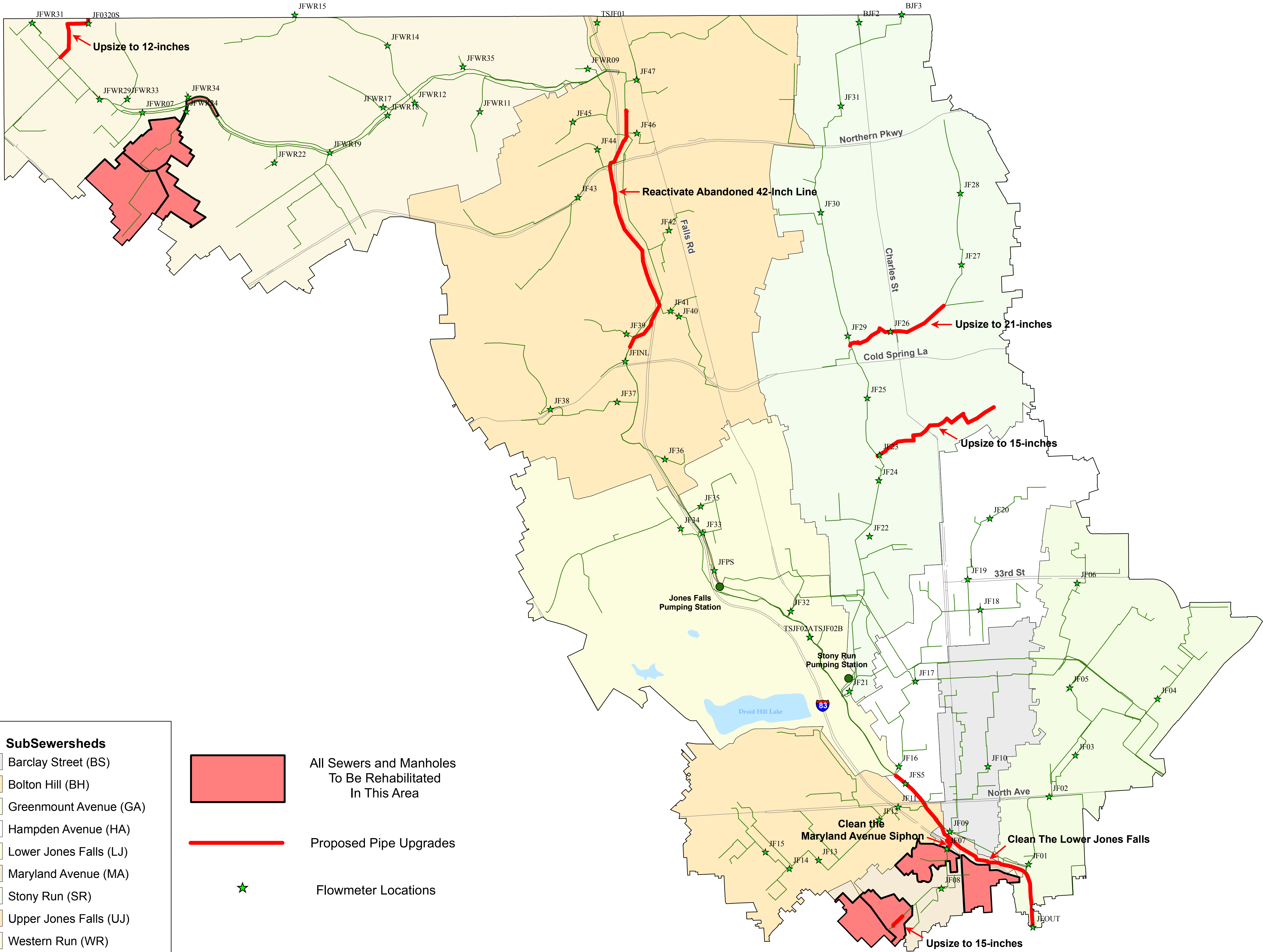
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**Jones Falls Sewershed
Project Area**



**Project 994 - Jones Falls
Collection System Evaluation
& Sewershed Plan**

Map 1.1



November 17, 2008

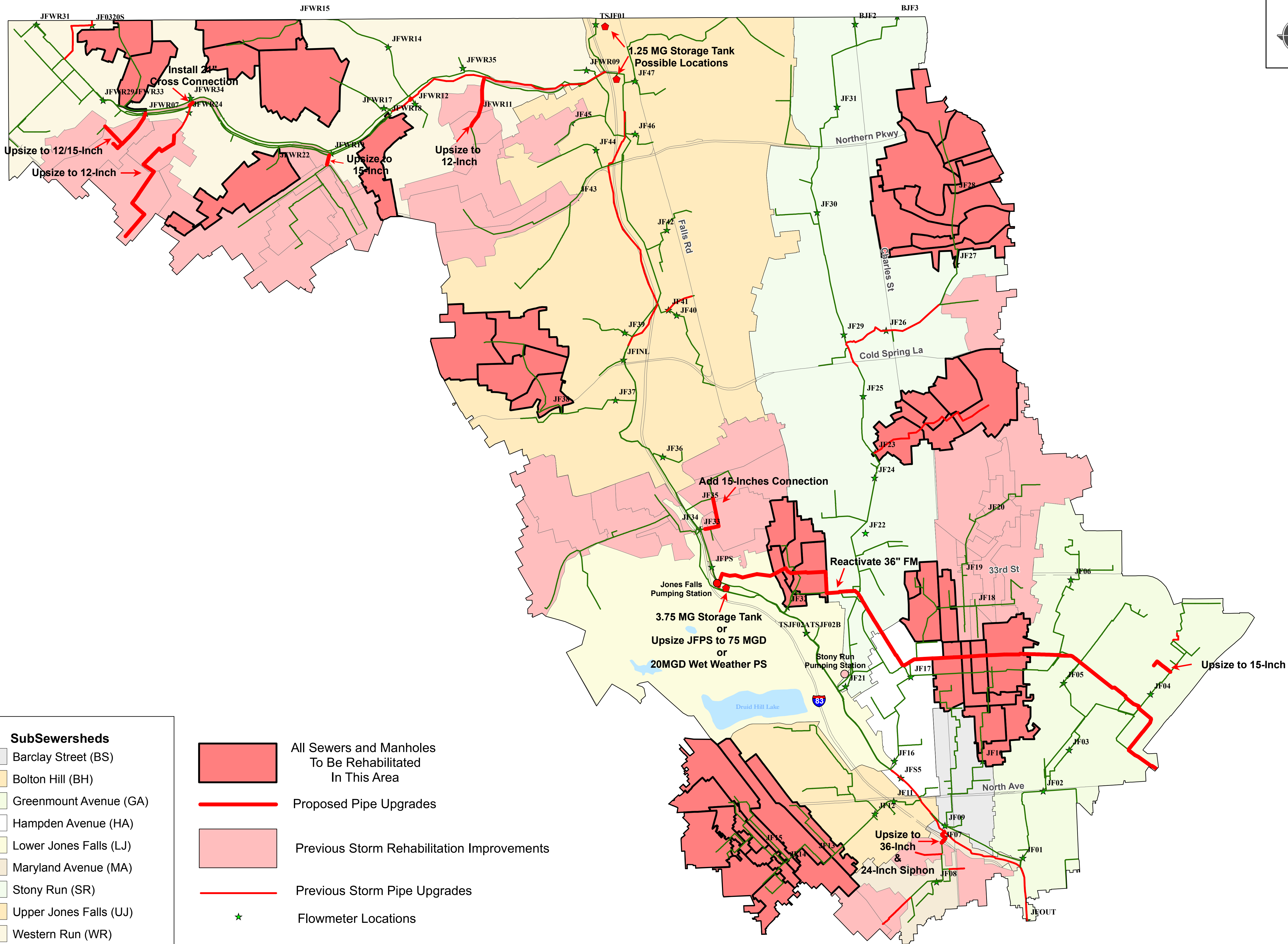
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Jones Falls Alternative Analysis (2-Year Storm)

Project 994 - Jones Falls Collection System Evaluation & Sewershed Plan



Map 2.0



SubSewersheds

- Barclay Street (BS)
- Bolton Hill (BH)
- Greenmount Avenue (GA)
- Hampden Avenue (HA)
- Lower Jones Falls (LJ)
- Maryland Avenue (MA)
- Stony Run (SR)
- Upper Jones Falls (UJ)
- Western Run (WR)

- All Sewers and Manholes To Be Rehabilitated In This Area
- Proposed Pipe Upgrades
- Previous Storm Rehabilitation Improvements
- Previous Storm Pipe Upgrades
- Flowmeter Locations

In association with

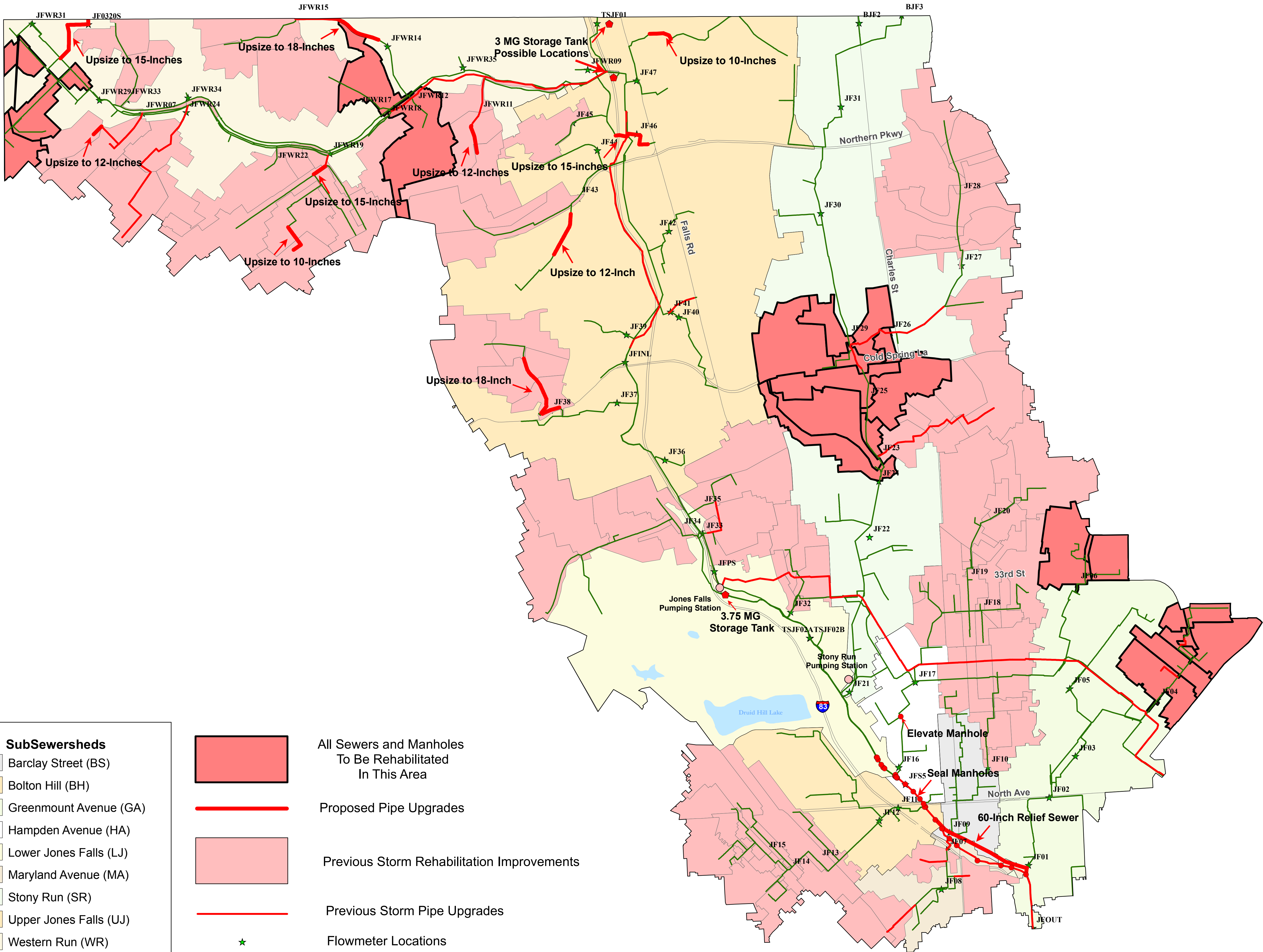
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Scale: 1 inch = 0.5 miles

Jones Falls
Alternative Analysis
(10-Year Storm)

Project 994 - Jones Falls
Collection System Evaluation
& Sewershed Plan



Map 4.0



SubSewersheds

Barclay Street (BS)

Bolton Hill (BH)

Greenmount Avenue (GA)

Hampden Avenue (HA)

Lower Jones Falls (LJ)

Maryland Avenue (MA)

Stony Run (SR)

Upper Jones Falls (UJ)

Western Run (WR)

All Sewers and Manholes To Be Rehabilitated In This Area

Proposed Pipe Upgrades

Previous Storm Rehabilitation Improvements

Previous Storm Pipe Upgrades

Flowmeter Locations

KCI
TECHNOLOGIES

In association with

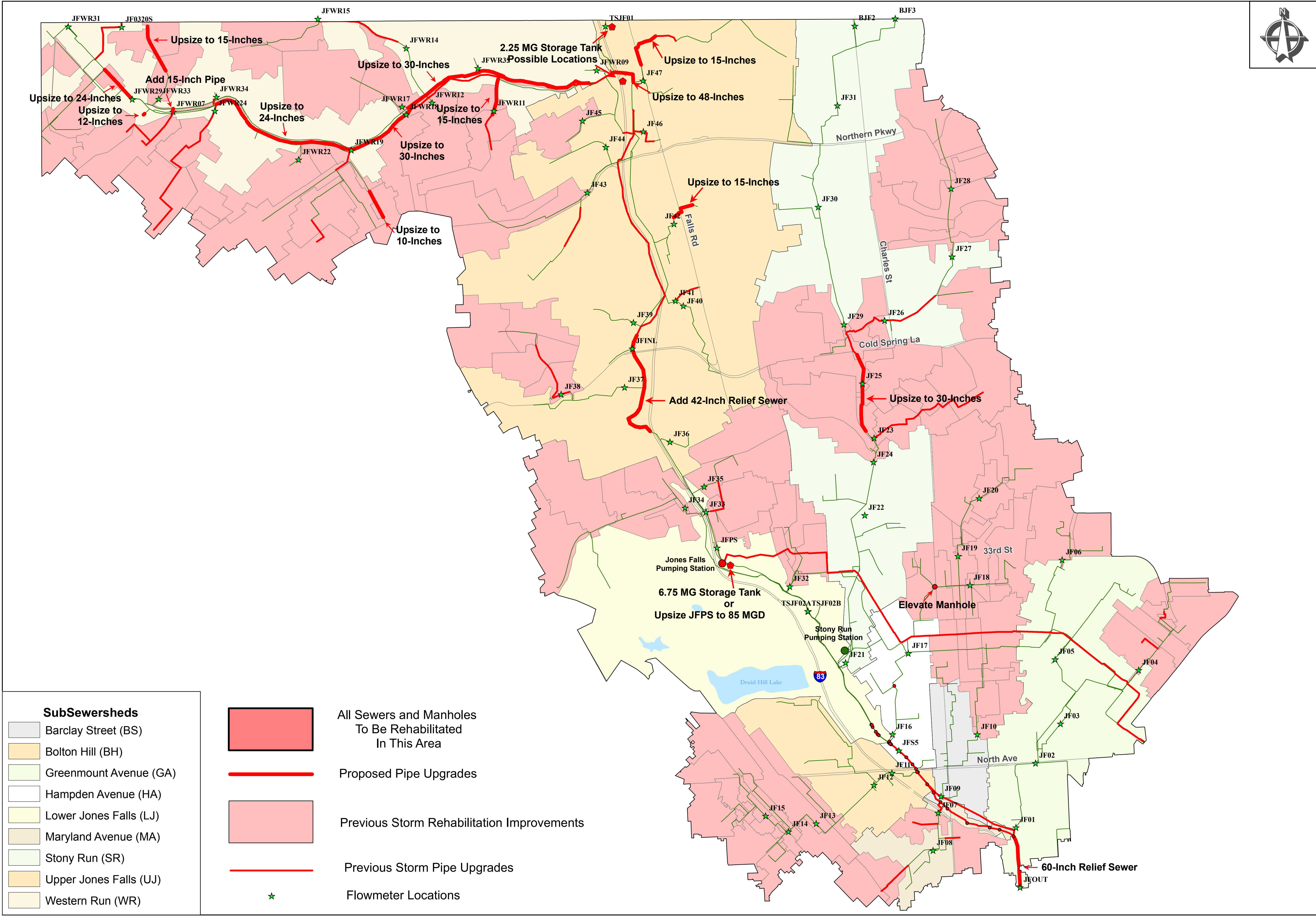
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Scale: 1 inch = 0.5 miles

Jones Falls
Alternative Analysis
(15-Year Storm)


Project 994 - Jones Falls
Collection System Evaluation
& Sewershed Plan

Map 5.0





In association with




November 17, 2008

Scale: 1 inch = 0.5 miles

Jones Falls Alternative Analysis (20-Year Storm)

Project 994 - Jones Falls Collection System Evaluation & Sewershed Plan



Map 6.0